PATENT ABSTRACTS OF JAPAN

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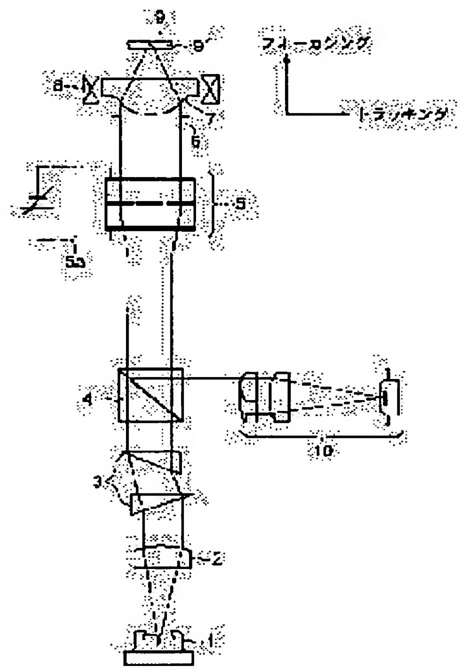
(54) OPTICAL SYSTEM FOR OPTICAL PICKUP, OPTICAL PICKUP DEVICE AND RECORDING/REPRODUCING DEVICE



(57)Abstract:

PROBLEM TO BE SOLVED: To provide an optical system for an optical pickup, an optical pickup device and recording/reproducing device which can effectively correct axial chromatic aberration caused by mode hopping or high-frequency superposing of a laser light source and which can also effectively compensate, through a simple structure, change in the oscillation wavelength of the laser light source, change in temperature and humidity, and fluctuation of spherical aberration caused by the thickness error of the protective layer of an optical information recording medium.

SOLUTION: This optical pickup is equipped with a converging optical system including an objective lens 7 and a coupling lens 2, which changes the divergence angle of divergent light emitted from a light source 1 with a wavelength λ of 500 nm or below to make the light enter an objective lens, while a diffraction face is possessed in at least two or more faces in the converging optical system. The optical pickup is also equipped with an element 5 for varying a refractive index profile, i.e., an element capable of compensating spherical aberrations or the like in each optical face by varying a refractive index profile, canceling and compensating the axial chromatic aberrations generated in other than the objective lens using longitudinal chromatic aberrations generated in the diffraction face.

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CLAIMS

[Claim(s)]
[Claim 1] Optical system for optical pickups characterized by changing the angle of divergence of the emission light to which outgoing radiation of the wavelength lambda was carried out from the light source 500nm or less, having the condensing optical system containing the coupling lens and objective lens for carrying out incidence to an objective lens, and having a diffraction side in the 2nd [at least / or more] page of said condensing optical system.
[Claim 2] Optical pickup equipment characterized by changing the angle of divergence of the emission light to which outgoing radiation of the wavelength lambda was carried out from the light source 500nm or less, having the condensing optical system containing the coupling lens and objective lens for carrying out incidence to an objective lens, and having a diffraction side in the 2nd [at least / or more] page of said condensing optical system.
[Claim 3] The objective lens which condenses the flux of light from the light source to the information recording surface of an optical information record medium, The coupling lens for changing the angle of divergence of the emission light by which outgoing radiation was carried out from said light source, and carrying out incidence to said objective lens, The refractive-index distribution adjustable component which can amend the spherical aberration produced in each optical surface by being arranged between said light sources and said objective lenses, and changing refractive-index distribution, Optical pickup equipment characterized by carrying out offset amendment of the axial overtone aberration which has a diffraction side in the 1st [at least] page of a preparation, said coupling lens, said refractive-index distribution adjustable component, and said objective lens, and is generated in optical elements other than said objective lens according to said axial overtone aberration which occurs in respect of diffraction.
[Claim 4] Optical pickup equipment according to claim 3 characterized by the axial overtone aberration of said synthetic system filling a degree type when change of the focal location of the synthetic system of said coupling lens and said objective lens when +10nm of wavelength of said light source changes is set to deltafB (micrometer) and image side numerical aperture of said objective lens is set to NAobj.
| deltafB and (NAobj) 2|<=2.5micrometer -- [Claim 5] The light source and the color correction optical element by which axial overtone aberration was superfluously amended to wavelength shorter 10nm than the criteria wavelength of said light source, By being arranged between the objective lens which condenses the flux of light from said light source to the information recording surface of an optical information record medium, and said light source and said objective lens, and changing refractive-index distribution Optical pickup equipment with which it has the refractive-index distribution adjustable component which can amend the spherical aberration produced in each optical surface, and said color correction optical element is characterized by carrying out offset amendment of the axial overtone aberration generated with said objective lens and said refractive-index distribution adjustable component.
[Claim 6] The angle of divergence of the emission light to which outgoing radiation of said color correction optical element was carried out from said light source is changed. Are a coupling lens for carrying out incidence to an objective lens, and change of the focal location of the synthetic system of said coupling lens and said objective lens when +10nm of wavelength of said light

source changes is set to deltafB (micrometer). Optical pickup equipment according to claim 5 characterized by the axial overtone aberration of said synthetic system filling a degree type when image side numerical aperture of said objective lens is set to NAobj.
| deltafB and (NAobj) 2|<=2.5micrometer -- [Claim 7] Optical pickup equipment given in claim 3 characterized by changing refractive-index distribution when the ingredient of said refractive-index distribution adjustable component divides and impresses electric field, a magnetic field, or temperature to this liquid crystal on the zona orbicularis including liquid crystal thru/or any 1 term of 6.
[Claim 8] As for said refractive-index distribution adjustable component, the laminating of a transparent electrode layer and the opto electronics material layer is carried out by turns. The transparence conductive layer by which the layer of the arbitration of said transparent electrode layers was divided on the zona orbicularis, and was divided in the shape of [the] zona orbicularis functions as two or more electrodes. Optical pickup equipment given in claim 3 characterized by changing refractive-index distribution by controlling electrically the refractive index of said opto electronics material layer using said two or more electrodes thru/or any 1 term of 6.
[Claim 9] Optical pickup equipment according to claim 7 or 8 characterized by the Abbe number of said refractive-index distribution adjustable component satisfying a degree type.
80>nud>10 -- [Claim 10] Optical pickup equipment given in claim 7 to which said refractive-index distribution adjustable component is characterized by applying a constant voltage near the field at which an optical axis is crossed thru/or any 1 term of 9.
[Claim 11] Optical pickup equipment according to claim 5 or 6 characterized by at least one field of said color correction optical element being the coupling lens which has diffraction structure.
[Claim 12] Optical system for optical pickups according to claim 1 characterized by forming said coupling lens from plastic material.
[Claim 13] Optical pickup equipment according to claim 2, 3, 4, or 11 characterized by forming said coupling lens from plastic material.
[Claim 14] Said diffraction side is optical system for optical pickups according to claim 1 or 12 characterized by being prepared in the field with which height h of a MAJINARU beam of light fills a degree type, when maximum of the height of a MAJINARU beam of light is set to hm.
It is [Claim 15] 0.5 hm<h<=hm. Said diffraction side is optical pickup equipment according to claim 2, 3, 4, 11, or 13 characterized by being prepared in the field with which height h of a MAJINARU beam of light fills a degree type, when maximum of the height of a MAJINARU beam of light is set to hm.
It is [Claim 16] 0.5 hm<h<=hm. Optical system for optical pickups according to claim 1, 12, or 14 characterized by said objective lens consisting of one sheet.
[Claim 17] Optical pickup equipment given in claim 2 characterized by said objective lens consisting of one sheet thru/or any 1 term of 4, 10, 13, and 15.
[Claim 18] Optical system for optical pickups according to claim 16 characterized by filling a degree type when thickness on the optical axis of said objective lens is set to d and a focal distance is set to f.
0.98>NA>0.70.81<d/f<3.0 -- [Claim 19] Optical pickup equipment according to claim 17 characterized by filling a degree type when thickness on the optical axis of said objective lens is set to d and a focal distance is set to f.
0.98>NA>0.70.81<d/f<3.0 -- [Claim 20] Optical system for optical pickups according to claim 16 or 18 characterized by said objective lens filling a degree type.
0.02< sigmaphichro/phi obj<0.30 -- here -- sigmaphichro -- the sum of the power of a diffraction lens side -- it is -- phiobj The power of an objective lens is shown.
[Claim 21] Optical pickup equipment according to claim 17 or 19 characterized by said objective lens filling a degree type.
0.02< sigmaphichro/phi obj<0.30 -- here -- sigmaphichro -- the sum of the power of a diffraction lens side -- it is -- phiobj The power of an objective lens is shown.
[Claim 22] Optical system for optical pickups according to claim 1 characterized by said objective lens consisting of two sheets.

[Claim 23] Optical pickup equipment given in claim 2 characterized by said objective lens consisting of two sheets thru/or any 1 term of 4, 11, 13, and 15.
[Claim 24] Optical system for optical pickups according to claim 22 characterized by said objective lens filling a degree type.
0.02< sigmaphichro/phi obj<0.25 -- here, sigmaphichro is the sum of the power of a diffraction lens side, and phiobj shows the power of an objective lens.
[Claim 25] Optical pickup equipment according to claim 23 characterized by said objective lens filling a degree type.
0.02< sigmaphichro/phi obj<0.25 -- here, sigmaphichro is the sum of the power of a diffraction lens side, and phiobj shows the power of an objective lens.
[Claim 26] Optical pickup equipment according to claim 6 characterized by said coupling lens consisting of forward and a two negative lens.
[Claim 27] Optical pickup equipment according to claim 26 characterized by the Abbe number of said coupling lens filling a degree type, respectively.
nudP>40.0nudN<60.0, however Abbe-number nudN of d line of a nudP:positive lens: The Abbe number of d line of a negative lens [claim 28] Optical pickup equipment according to claim 26 or 27 which said objective lens consists of one lens, and thickness on the optical axis of said lens is set to d, it sets a focal distance to f, and is characterized by filling a degree type.
0.98>NA>0.70.81<d/f<3.0 -- [Claim 29] Optical pickup equipment according to claim 26 or 27 characterized by said objective lens consisting of two lenses.
[Claim 30] Claim 3 characterized by having further the optical-path division component which is arranged between said light source and said refractive-index distribution adjustable component, and carries out the monitor of the condition of the wave aberration in an image formation side 11, 13, 15, 17, 19, 21, 23 and 25 thru/or optical pickup equipment given in any 1 term of 29.
[Claim 31] The voice characterized by carrying the optical pickup equipment of a publication in any 1 term of claim 2 11, 13, 15, 17, 19, 21, 23 and 25 thru/or 30, the recording device of an image, voice, and/or the regenerative apparatus of an image.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the optical system for optical pickups for record of the information on an optical information record medium, and/or playback, optical pickup equipment, and the record and the regenerative apparatus containing this optical pickup equipment.
[0002]
[Description of the Prior Art] If short-wavelength-izing of a laser light source and high numerical-aperture-ization of an objective lens are attained, in the optical pickup equipment which consists of combination of a laser light source of long wavelength and an objective lens of a low numerical aperture which perform informational record or playback to the conventional optical disk like CD or DVD comparatively, being actualized more will be expected also on the almost disregarded problem.
[0003] One of them is the problem of the axial overtone aberration produced in an objective lens by fluctuation of the very small oscillation wavelength of a laser light source. The refractive-index change by the very small wavelength variation of a common optical lens ingredient becomes so large that short wavelength is dealt with. Therefore, for time, the depth of focus of an objective lens is [. to which the amount of defocusing of the focus produced by very small wavelength variation becomes large, and] k-lambda. The depth of focus becomes small and few amounts of defocusing are not allowed, either, so that it may understand from being expressed with /NA2 (wavelength and NA being [k] the image side numerical aperture of an objective lens for a proportionality constant and lambda) and operating wavelength is short. Therefore, in the optical system using the light source and the objective lens of high numerical aperture of short wavelength like purple-blue color semiconductor laser, in order to prevent degradation of the mode hop phenomenon of semiconductor laser, the wavelength variation by output change, and the wave aberration by RF superposition, amendment of axial overtone aberration becomes important.
[0004] Furthermore, another problem actualized in short-wavelength-izing of a laser light source and a raise in the numerical aperture of an objective lens is fluctuation of the spherical aberration of the optical system by temperature and humidity. That is, the plastic lens currently generally used in optical pickup equipment is easy to deform in response to temperature or humidity, and a refractive index changes a lot. In the optical system used for conventional optical pickup equipment, fluctuation of the spherical aberration by refractive-index change it was so much changeless on a problem also serves as an amount which cannot be disregarded in short-wavelength-izing of a laser light source, and a raise in the numerical aperture of an objective lens.
[0005] Furthermore, another problem actualized in short-wavelength-izing of a laser light source and a raise in the numerical aperture of an objective lens is fluctuation of the spherical aberration of the optical system resulting from the thickness error of the protective layer (it is also called a transparence substrate) of an optical disk. Generating the spherical aberration produced according to the thickness error of a protective layer in proportion to the 4th power of

the numerical aperture of an objective lens is known. Therefore, there is a possibility that the effect of the thickness error of a protective layer may become large, and record or playback of the stable information may become impossible as the numerical aperture of an objective lens becomes large.
[0006] Moving mechanically spacing of the coupling lens and said objective lens for changing the angle of divergence of the emission light by which outgoing radiation was carried out from the light source as the technique of amending fluctuation of the spherical aberration generated in the above reasons, and carrying out incidence to an objective lens, amending spherical aberration, and connecting a spot on the information recording surface of an optical information record medium has been performed.
[0007] However, it is disadvantageous for lightweight-izing of optical pickup equipment, and a cost cut to move the whole lens system or a part, and it is desirable that the above-mentioned spherical aberration etc. can be amended without moving a lens system.
[0008]
[Problem(s) to be Solved by the Invention] This invention aims at offering the optical system for optical pickups, the optical pickup equipment, and the record and the regenerative apparatus which can amend effectively the axial overtone aberration which originates in the mode hop phenomenon of a laser light source, or RF superposition, and is generated with an objective lens.
[0009] Moreover, it aims at offering optical pickup equipment, and record and a regenerative apparatus equipped with the refractive-index part good light variation study component which can amend effectively fluctuation of the spherical aberration which originates in the error of the thickness of the protective layer of oscillation wavelength change of a laser light source, temperature and humidity, and an optical information record medium etc., and is generated in each optical surface of optical pickup equipment with a simple configuration.
[0010]
[Means for Solving the Problem] In order to attain the above-mentioned purpose, the optical system for optical pickups by this invention changes the angle of divergence of the emission light to which outgoing radiation of the wavelength lambda was carried out from the light source 500nm or less, is equipped with the condensing optical system containing the coupling lens and objective lens for carrying out incidence to an objective lens, and is characterized by having a diffraction side in the 2nd [at least / or more] page of said condensing optical system.
[0011] According to this optical system for optical pickups, by changing the angle of divergence of the emission light to which outgoing radiation of the wavelength lambda was carried out from the light source 500nm or less, and having a diffraction side in the 2nd [at least / or more] page of the condensing optical system containing the coupling lens and objective lens for carrying out incidence to an objective lens, the diameter of a spot can be made small and axial overtone aberration can be amended good.
[0012] Moreover, the 1st optical pickup equipment by this invention changes the angle of divergence of the emission light to which outgoing radiation of the wavelength lambda was carried out from the light source 500nm or less, is equipped with the condensing optical system containing the coupling lens and objective lens for carrying out incidence to an objective lens, and is characterized by having a diffraction side in the 2nd [at least / or more] page of said condensing optical system.
[0013] According to this optical pickup equipment, by changing the angle of divergence of the emission light to which outgoing radiation of the wavelength lambda was carried out from the light source 500nm or less, and having a diffraction side in the 2nd [at least / or more] page of the condensing optical system containing the coupling lens and objective lens for carrying out incidence to an objective lens, the diameter of a spot can be made small and axial overtone aberration can be amended good.
[0014] Moreover, the 2nd optical pickup equipment by this invention The objective lens which condenses the flux of light from the light source to the information recording surface of an optical information record medium, The coupling lens for changing the angle of divergence of the emission light by which outgoing radiation was carried out from said light source, and carrying out incidence to said objective lens, The refractive-index distribution adjustable component

which can amend the spherical aberration produced in each optical surface by being arranged between said light sources and said objective lenses, and changing refractive-index distribution, It has a diffraction side in the 1st [at least] page of a preparation, said coupling lens, said refractive-index distribution adjustable component, and said objective lens, and is characterized by carrying out offset amendment of the axial overtone aberration generated in optical elements other than said objective lens according to said axial overtone aberration which occurs in respect of diffraction.

[0015] By changing refractive-index distribution with the refractive-index distribution adjustable component arranged between the coupling lens for according to this optical pickup equipment changing the angle of divergence of the emission light by which outgoing radiation was carried out from the light source, and carrying out incidence to an objective lens, and an objective lens Amendment can do spherical aberration produced in each optical surface, and the axial overtone aberration which was prepared in the 1st [at least] page of the equipment of a coupling lens, a refractive-index distribution adjustable component, and an objective lens and which is generated in optical elements other than a diffraction lens in respect of diffraction can be amended good.

[0016] Moreover, in the 2nd optical pickup equipment, when change of the focal location of the synthetic system of said coupling lens and said objective lens when +10nm of wavelength of said light source changes is set to deltafB (micrometer) and image side numerical aperture of said objective lens is set to NAobj, it is desirable that the axial overtone aberration of said synthetic system fills a degree type (1).

[0017]

| deltafB and (NAobj) 2|<=2.5micrometer (1)

[0018] Moreover, the 3rd optical pickup equipment by this invention The light source and the color correction optical element by which axial overtone aberration was superfluously amended to wavelength shorter 10nm than the criteria wavelength of said light source, By being arranged between the objective lens which condenses the flux of light from said light source to the information recording surface of an optical information record medium, and said light source and said objective lens, and changing refractive-index distribution It has the refractive-index distribution adjustable component which can amend the spherical aberration produced in each optical surface, and said color correction optical element is characterized by carrying out offset amendment of the axial overtone aberration generated with said objective lens and said refractive-index distribution adjustable component.

[0019] With this optical pickup equipment, the axial overtone aberration generated with the refractive-index distribution adjustable component which amends the wave aberration produced in each optical surface, and an objective lens can be offset by the color correction optical element.

[0020] Moreover, the angle of divergence of the emission light to which outgoing radiation of said color correction optical element was carried out from said light source in the 3rd optical pickup equipment is changed. Are a coupling lens for carrying out incidence to an objective lens, and change of the focal location of the synthetic system of said coupling lens and said objective lens when +10nm of wavelength of said light source changes is set to deltafB (micrometer). When image side numerical aperture of said objective lens is set to NAobj, it is desirable that the axial overtone aberration of said synthetic system fills a degree type (2).

[0021]

| deltafB and (NAobj) 2|<=2.5micrometer (2)

[0022] Moreover, when the ingredient of said refractive-index distribution adjustable component divides and impresses electric field, a magnetic field, or temperature to this liquid crystal on the zona orbicularis including liquid crystal in the 2nd or 3rd optical pickup equipment, it is desirable to change refractive-index distribution. Thus, by dividing and impressing electric field, a magnetic field, or temperature to the liquid crystal of the ingredient of a refractive-index distribution adjustable component on the zona orbicularis, refractive-index distribution almost symmetrical with a core can be formed to the optical axis of optical system, and aberration, such as spherical aberration generated except a refractive-index distribution adjustable component, can be amended.

[0023] In the 2nd or 3rd optical pickup equipment moreover, said refractive-index distribution adjustable component The laminating of a transparent electrode layer and the opto electronics material layer is carried out by turns, and the layer of the arbitration of said transparent electrode layers is divided on the zona orbicularis. When the transparence conductive layer divided in the shape of [the] zona orbicularis functions as two or more electrodes and controls electrically the refractive index of said opto electronics material layer using said two or more electrodes, it is desirable to change refractive-index distribution. By changing refractive-index distribution by such control, refractive-index distribution almost symmetrical with a core can be formed to the optical axis of optical system, and aberration, such as spherical aberration generated except a refractive-index distribution adjustable component, can be amended.
[0024] Moreover, the Abbe number of said refractive-index distribution adjustable component can amend the spherical aberration generated from other optical elements, such as an objective lens, good by satisfying a degree type (3).
[0025] 80>nud> 10 (3)
[0026] Moreover, by applying a constant voltage near the field at which said refractive-index distribution adjustable component crosses an optical axis, the distribution to which a refractive index becomes small, or its reverse distribution can be easily formed, so that a refractive-index distribution adjustable component approaches the field at which an optical axis is crossed.
[0027] Moreover, when at least one field of said color correction optical element is the coupling lens which has diffraction structure, the offset amendment of the axial overtone aberration generated in other optical elements, such as an objective lens, can be carried out good.
[0028] Moreover, diffraction structure and the aspheric surface can be added easily, and it can mass-produce by said coupling lens being formed from plastic material cheaply.
[0029] Moreover, when maximum of the height of a MAJINARU beam of light is set to hm, as for said diffraction side, it is desirable to be prepared in the field with which height h of a MAJINARU beam of light fills a degree type (4).
[0030]
0.5 hm<h<=hm (4)
[0031] By making it fill an above-mentioned formula (4), since the zona-orbicularis pitch in the MAJINARU beam-of-light height of a diffraction lens can be enlarged, decline in the efficiency for light utilization by the blaze configuration error can be suppressed. For example, when approximated by the light-gage lens model, the axial overtone aberration of optical system is expressed with the several 1 following formula.
[0032]
[Equation 1]

$$\delta s'_\alpha = -\left(\frac{s'_\alpha}{h_1}\right)^2 \sum_{j=1}^{\alpha} \frac{\phi_j h_j^2}{\nu_j}$$

S'α ：最終レンズからガウス像面までの距離

Here, phij (j= 1, 2 and 3, —, alpha) is the refractive power of each thin lens, hj (j= 1, 2 and 3, —, alpha) is the height from the optical axis of the MAJINARU beam of light which passes along each thin lens, and nuj (j= 1, 2 and 3, —, alpha) is the Abbe number of each lens.
[0033] Here, a diffraction side is established in the k-th lens, and a part of the refractive power is given to a diffraction side. If the refractive power by diffraction is expressed as phid, the refractive power of the k-th lens will be permuted by phik=(phik-phid)+phid, and I make refractive-power phid according (phik-phid) to refraction into the refractive power by diffraction, and think that those lenses stick and it is arranged. At this time, the Abbe number of the part of (phik-phid) is set to nuk, and the Abbe number of phid writes nud as the Abbe number of a diffraction side. If this formula is substituted for several 1 above-mentioned formula and the

following achromatic condition is used, the several 2 following formula will be drawn.
[0034]
[Equation 2]

$$\sum_{j=1}^{\alpha}\frac{\phi_j h_j^2}{\nu_j}+\left(\frac{1}{\nu_d}-\frac{1}{\nu_k}\right)\phi_d h_k^2=0$$

色消し条件 $\delta S'_\alpha=0$

Therefore, refractive-power phid of a diffraction side required for achromatism can be expressed with the several 3 following formula.
[0035]
[Equation 3]

$$\phi_d=\left(\sum_{j=1}^{\alpha}\frac{\phi_j h_j^2}{\nu_j}\right)\Bigg/\left(\frac{1}{\nu_k}-\frac{1}{\nu_d}\right)h_k^2=\frac{C}{h_k^2}$$

Here, C in several 3 above-mentioned formula can be expressed with the several 4 following formula.
[0036]
[Equation 4]

$$C=\left(\sum_{j=1}^{\alpha}\frac{\phi_j h_j^2}{\nu_j}\right)\Bigg/\left(\frac{1}{\nu_k}-\frac{1}{\nu_d}\right)$$

On the other hand, since the optical-path-difference function of a diffraction side is almost the 2nd order because of achromatism, an optical-path-difference function can be expressed with the several 5 following formula when phid is used.
[0037]
[Equation 5]

$$\Phi(h)=\frac{1}{2}\phi_d h^2$$

The zona-orbicularis pitch in the height hk of a MAJINARU beam of light when the shape of zona orbicularis blaze-izes this diffraction side at this time will serve as the several 6 following formula, if several 3 above-mentioned formula is used.
[0038]
[Equation 6]

$$P(h_k) = \frac{m\lambda}{\frac{d\Phi}{dh}} = \frac{m\lambda h_k}{C}$$

This several 6 formula shows that the height of a MAJINARU beam of light, i.e., the zona-orbicularis pitch in the maximum circumference part of the effective diameter of each lens, is proportional to that beam-of-light height. Therefore, as for a zona-orbicularis pitch, the direction where MAJINARU beam-of-light quantity arranges a diffraction side to a high field becomes large. Decline in the diffraction efficiency by the blaze configuration error of each zona orbicularis occurs, so that a zona-orbicularis pitch is large, and it is a difficulty pile.
[0039] Moreover, a cost cut and lightweight-izing of optical pickup equipment can be attained because said objective lens consists of one sheet.
[0040] Moreover, when thickness on the optical axis of said objective lens is set to d and a focal distance is set to f, it is desirable to fill a degree type (5) and (6). They are conditions for a formula (6) and NA to acquire a good image quantity property in a larger single ball lens than 0.70.
[0041]
0.98>NA>0.7 (5)
0.81<d/f<3.0 (6)
[0042] Moreover, when said objective lens fills a degree type (7), the axial overtone aberration of a synthetic system can be amended good.
[0043]
0.02< sigmaphichro/phi obj<0.30 (7)
Here, sigmaphichro is the sum of the power of a diffraction lens side, and is phiobj. The power of an objective lens is shown.
[0044] Moreover, the axial overtone aberration of a synthetic system can be amended good by said objective lens consisting of two sheets.
[0045] The axial overtone aberration of a synthetic system can be amended good because said objective lens fills a degree type (8).
[0046]
0.02< sigmaphichro/phi obj<0.25 (8)
Here, sigmaphichro is the sum of the power of a diffraction lens side, and phiobj shows the power of an objective lens.
[0047] Moreover, the offset amendment of the axial overtone aberration generated by other optical elements, such as an objective lens, because said coupling lens consists of forward and a two negative lens can be carried out good.
[0048] Moreover, if it is made for the Abbe number of said coupling lens to fill a degree type (9) and (10), respectively, the coupling lens of the still better engine performance can be obtained.
[0049] nudP> 40.0 (9)
[0050] nudN<60.0 (10)
However, Abbe-number nudN of d line of a nudP:positive lens: The Abbe number of d line of a negative lens [0051] Moreover, it is desirable for said objective lens to consist of one lens, and to set thickness on the optical axis of said lens to d, it to set a focal distance to f, and to fill a degree type. Formulas (12) are conditions for NA to acquire a good image quantity property in a larger single ball lens than 0.70.
[0052]
0.98>NA>0.7 (11)
0.81<d/f<3.0 (12)
[0053] Moreover, the axial overtone aberration of a synthetic system can be amended good by said objective lens consisting of two lenses.
[0054] Moreover, it is desirable to have further the optical-path division component which is

arranged between said light source and said refractive-index distribution adjustable component, and carries out the monitor of the condition of the wave aberration in an image formation side. When a monitor etc. carries out the condition of the wave aberration in an image formation side with an optical-path division component, a spot can be connected good on an information recording surface to change of the information recording surface cover layer thickness of for example, an optical information record medium by changing refractive-index distribution of a refractive-index distribution adjustable component from the information on the wave aberration of an image formation side.

[0055] Moreover, the record and the regenerative apparatus by this invention carry above-mentioned optical pickup equipment, and performs playback of record of voice and/or an image, voice, and/or an image.

[0056] Since according to this record and regenerative apparatus the axial overtone aberration which originates in the mode hop phenomenon of a laser light source or RF superposition, and is generated with an objective lens is amended effectively and fluctuation of the spherical aberration which originates in the error of the thickness of the protective layer of oscillation wavelength change of a laser light source, temperature and humidity, and an optical information record medium etc., and is generated in each optical surface can be amended effectively, record and playback can be performed stably and correctly.

[0057]

[Embodiment of the Invention] Hereafter, the gestalt of operation by this invention is explained using a drawing. Drawing 1 is drawing showing roughly the optical system for optical pickups by the gestalt of operation of this invention, and optical pickup equipment.

[0058] With the optical pickup equipment (optical system for optical pickups) shown in drawing 1 , the flux of light from the laser light source 1 whose wavelength lambda is about 400nm passes the coupling lens 2, the prism pair 3, the deviation beam splitter 4, the refractive-index distribution adjustable component 5, and diaphragm 6, and is condensed by the information recording surface 9 through protective layer 9' of an optical information record medium with an objective lens 7. It is reflected by the deviation beam splitter 4 and the reflected light from the information recording surface 9 goes to the photodetector system 10, after passing an objective lens 7 and refractive-index distribution adjustable component 5 grade. An objective lens 7 is driven in the direction of focusing, and the direction of tracking with the biaxial actuator 8.

[0059] Moreover, although the optical pickup equipment of drawing 1 is not illustrated, it detects fluctuation of the spherical aberration generated according to condensing optical system by detecting the reflected light from the information recording surface 9, and has a spherical-aberration detection means to generate a spherical-aberration error signal based on the detection result. The refractive-index distribution adjustable component as a spherical-aberration amendment means is made to drive so that a spherical-aberration error signal may become zero. What is indicated by the application for patent No. 108378 [2001 to] by the same applicant, for example as the spherical-aberration detection approach in such a spherical-aberration detection means and a spherical-aberration detection means can be used. In addition, an above-mentioned spherical-aberration detection means is arranged in the optical path between a spherical-aberration amendment means and the light source.

[0060] Moreover, the refractive-index distribution adjustable component 5 is arranged between the coupling lens 2 and an objective lens 7, and amends fluctuation of the spherical aberration which originates in the error of the thickness of protective layer 9' of oscillation wavelength change of a laser light source 1, temperature and humidity, and an optical information record medium etc., and is generated in each optical surface. That is, when spherical aberration is changed in the condensing optical system of drawing 1 , fluctuation of this spherical aberration is detected by the photodetector system 10, and based on this detected spherical-aberration error signal, driving means 5a drives the refractive-index distribution adjustable component 5, and amends spherical aberration.

[0061] Next, drawing 2 and drawing 3 explain the example of the refractive-index distribution adjustable component 5 of drawing 1 .

[0062] The laminating of the refractive-index distribution adjustable components d and e from

which refractive-index distribution changes according to the electrical potential difference which it connects electrically, and the refractive-index adjustable component shown in drawing 2 is electrically insulated to the transparent electrode layers a, b, and c and the electrode layers a, b, and c optically, and is impressed from a driving means A is carried out by turns, they are formed, and the electrode layers a, b, and c are divided into the shape of zona orbicularis to two or more fields.
[0063] With the refractive-index adjustable component of drawing 2 , the seal of approval of the electrical potential difference is carried out to the electrode layers a, b, and c of the shape of two or more zona orbicularis from a driving means A, and aberration, such as spherical aberration which can form refractive-index distribution almost symmetrical with a core to the optical axis of optical system by driving the refractive-index distribution adjustable components d and e, and is generated except a refractive-index distribution adjustable component, can be amended.
[0064] The closure of the liquid crystal 1i is carried out by the seal members 1g and 1h, and the refractive-index adjustable component shown in drawing 3 is pinched among the transparence substrates 1a and 1b which formed the transparent electrode layers 1c and 1d. The orientation film 1e and 1f is formed inside the transparence substrates 1a and 1b, and the transparent electrode layers 1c and 1d are divided into plurality in the shape of zona orbicularis. By changing the refractive index of liquid crystal i from a driving means A in the shape of zona orbicularis according to the electrical potential difference by which a seal of approval is carried out, aberration, such as spherical aberration generated except a refractive-index distribution adjustable component, can be amended.
[0065]
[Example] Next, examples 1-4 explain this invention still more concretely. A list of the data about the coupling lens in each examples 1-4, an objective lens, and a synthetic system is shown in the next table 1.
[0066]
[Table 1]

実施例1

使用波長 λ (nm)		405
カップリングレンズ	レンズ枚数	1
	回折面数	1
対物レンズ	レンズ枚数	1
	回折面数	1
	NA	0.85
	d/f	1.56
合成系	回折面数	2
	h1/hm	0.85
	h2/hm	1.00
	$\|\Delta fb\|$ (μm)	1.01
	$\|\Delta fb \cdot (NA_{obj})^2\|$ (μm)	0.73
	$\Sigma\phi_{ono}/\phi_{obj}$	6.34E-02

実施例2

使用波長 λ (nm)		405
カップリングレンズ	レンズ枚数	1
	回折面数	2
対物レンズ	レンズ枚数	2
	回折面数	0
	NA	0.85
合成系	回折面数	2
	h1/hm	0.98
	h2/hm	1.00
	$\|\Delta fb\|$ (μm)	0.19
	$\|\Delta fb \cdot (NA_{obj})^2\|$ (μm)	0.14
	$\Sigma\phi_{ono}/\phi_{obj}$	7.94E-02

実施例3

使用波長 λ (nm)		405
カップリングレンズ	レンズ枚数	2
	回折面数	0
	νdP	54.7
	νdN	23.8
対物レンズ	レンズ枚数	2
	回折面数	0
	NA	0.85
合成系	回折面数	0
	$\|\Delta fb\|$ (μm)	0.03
	$\|\Delta fb \cdot (NA_{obj})^2\|$ (μm)	0.02

実施例4

使用波長 λ (nm)		405
カップリングレンズ	レンズ枚数	1
	回折面数	2
対物レンズ	レンズ枚数	1
	回折面数	0
	NA	0.85
	d/f	1.50
合成系	回折面数	2
	h1/hm	0.85
	h2/hm	1.00
	$\|\Delta fb\|$ (μm)	1.29
	$\|\Delta fb \cdot (NA_{obj})^2\|$ (μm)	0.83
	$\Sigma\phi_{ono}/\phi_{obj}$	1.04E-01

※ここでh1、h2は回折レンズ面を通過するマージナル光線の高さである。

[0067] Moreover, the wave aberration data amendment before by the refractive-index distribution component in each examples 1-4 and after amendment are shown in the next table 2.

[0068]

[Table 2]

実施例1
(単玉)
回折面2面

球面収差変動の要因		補正前の波面収差	補正後の波面収差	屈折率分布
基準状態		0.006λ	0.006λ	
LDの波長変動	Δλ=+10nm	0.066λ	0.008λ	$n(R)=n_0(\lambda)-0.6084\mathrm{e}{-6}R^4$
	Δλ=-10nm	0.077λ	0.011λ	$n(R)=n_0(\lambda)+0.8007\mathrm{e}{-5}R^4$
温度変化	ΔT=+30℃	0.073λ	0.006λ	$n(R)=n_0(\lambda)+0.7138\mathrm{e}{-5}R^4$
	ΔT=-30℃	0.078λ	0.01λ	$n(R)=n_0(\lambda)+0.1726\mathrm{e}{-3}R^4$
透明基板厚さ誤差	Δt=+0.02mm	0.195λ	0.006λ	$n(R)=n_0(\lambda)+0.3433\mathrm{e}{-4}R^4$
	Δt=-0.02mm	0.188λ	0.008λ	$n(R)=n_0(\lambda)+0.4451\mathrm{e}{-3}R^4$

実施例2
回折コリ+2枚対物

球面収差変動の要因		補正前の波面収差	補正後の波面収差	屈折率分布
基準状態		0.004λ	0.004λ	
LDの波長変動	Δλ=+10nm	0.056λ	0.006λ	$n(R)=n_0(\lambda)+0.6640\mathrm{e}{-5}R^4-0.2711\mathrm{e}{-4}R^6$
	Δλ=-10nm	0.063λ	0.008λ	$n(R)=n_0(\lambda)-0.2506\mathrm{e}{-4}R^4+0.3635\mathrm{e}{-4}R^6$
温度変化	ΔT=+30℃	0.014λ	0.004λ	$n(R)=n_0(\lambda)-0.1045\mathrm{e}{-3}R^4-0.2338\mathrm{e}{-4}R^6$
	ΔT=-30℃	0.014λ	0.004λ	$n(R)=n_0(\lambda)-0.1085\mathrm{e}{-3}R^4+0.2690\mathrm{e}{-4}R^6$
透明基板厚さ誤差	Δt=+0.02mm	0.194λ	0.008λ	$n(R)=n_0(\lambda)-0.1839\mathrm{e}{-4}R^4-0.8407\mathrm{e}{-4}R^6$
	Δt=-0.02mm	0.201λ	0.010λ	$n(R)=n_0(\lambda)-0.4350\mathrm{e}{-4}R^4+0.1096\mathrm{e}{-3}R^6$

実施例3
2枚コリ+2枚対物

球面収差変動の要因		補正前の波面収差	補正後の波面収差	屈折率分布
基準状態		0.006λ	0.006λ	
LDの波長変動	Δλ=+10nm	0.038λ	0.004λ	$n(R)=n_0(\lambda)+0.5831\mathrm{e}{-4}R^4-0.3160\mathrm{e}{-4}R^6$
	Δλ=-10nm	0.056λ	0.008λ	$n(R)=n_0(\lambda)-0.2277\mathrm{e}{-5}R^4+0.2785\mathrm{e}{-4}R^6$
温度変化	ΔT=+30℃	0.018λ	0.015λ	$n(R)=n_0(\lambda)+0.1764\mathrm{e}{-4}R^4-0.1153\mathrm{e}{-5}R^6$
	ΔT=-30℃	0.011λ	0.004λ	$n(R)=n_0(\lambda)-0.7082\mathrm{e}{-4}R^4+0.1908\mathrm{e}{-4}R^6$
透明基板厚さ誤差	Δt=+0.02mm	0.197λ	0.006λ	$n(R)=n_0(\lambda)+0.5860\mathrm{e}{-5}R^4-0.8651\mathrm{e}{-4}R^6$
	Δt=-0.02mm	0.190λ	0.020λ	$n(R)=n_0(\lambda)-0.3127\mathrm{e}{-4}R^4+0.1108\mathrm{e}{-3}R^6$

実施例4
(単玉)
回折コリ+1枚対物

球面収差変動の要因		補正前の波面収差	補正後の波面収差	屈折率分布
基準状態		0.005λ	0.005λ	
LDの波長変動	Δλ=+10nm	0.142λ	0.007λ	$n(R)=n_0(\lambda)+0.1039\mathrm{e}{-6}R^4-0.6275\mathrm{e}{-4}R^6$
	Δλ=-10nm	0.148λ	0.017λ	$n(R)=n_0(\lambda)-0.8168\mathrm{e}{-4}R^4+0.9889\mathrm{e}{-4}R^6$
温度変化	ΔT=+30℃	0.164λ	0.008λ	$n(R)=n_0(\lambda)+0.4840\mathrm{e}{-4}R^4-0.8303\mathrm{e}{-4}R^6$
	ΔT=-30℃	0.154λ	0.007λ	$n(R)=n_0(\lambda)-0.2373\mathrm{e}{-2}R^2-0.1533\mathrm{e}{-3}R^4$
透明基板厚さ誤差	Δt=+0.02mm	0.198λ	0.007λ	$n(R)=n_0(\lambda)+0.1982\mathrm{e}{-2}R^2$
	Δt=-0.02mm	0.190λ	0.009λ	$n(R)=n_0(\lambda)-0.1922\mathrm{e}{-2}R^2$

※光軸をZ軸とすると $R^2=X^2+Y^2$

[0069] In addition, the aspheric surface in the lens of this example expresses [height] the radius of curvature of h and a refracting interface with the following several 7 for the direction of an optical axis, when setting the height of a direction perpendicular to the X-axis and an optical axis to r. However, let a circular-cone multiplier and A2i be aspheric surface multipliers for kappa.

[0070]

[Equation 7]

$$X=\frac{h^2/r}{1+\sqrt{1-(1+\kappa)h^2/r^2}}+\sum_{i=2}A_{2i}h^{2i}$$

[0071] Moreover, the following several 8 can express the diffraction side of the shape of zona orbicularis prepared in the lens of this example as optical-path-difference function phib. Here, h is height perpendicular to an optical axis, and b2i is the multiplier of an optical-path-difference function.

[0072]

[Equation 8]

$$\Phi_b=\sum_{i=1}b_{2i}h^{2i}$$

[0073] (Example 1)

[0074] In drawing 1 , purple-blue color semiconductor laser with a wavelength of 405nm was used for the light source, and the objective lens of numerical aperture 0.85 was used by one group [one]. Axial overtone aberration was amended by forming a diffraction side in the light source side of an objective lens the light source side of an one one group coupling lens, respectively. Moreover, the aberration of a synthetic system was delicately amended by making the field by the side of the optical information record medium of a coupling lens, and both sides of an objective lens into the aspheric surface. Fluctuation of the spherical aberration resulting from the error of protection thickness, the wavelength variation of laser light source **, etc. was

amended with the refractive-index distribution adjustable component arranged between a coupling lens and an objective lens. The optical-path Fig. of an example 1 is shown in drawing 4 . Moreover, the lens data of an example 1 are shown in the next table 3.
[0075]
[Table 3]

実施例1

面番号		r(mm)	d(mm)	Nλ	νd
0	光源		7.929		
1	カップリング	∞	1.000	1.525	56.5
2	レンズ	-5.587	5.000		
3	偏光板	∞	2.000	1.53	64.1
4	基板	∞	1.000	1.53	64.1
5	液晶	∞	0.800	1.53	*
6	基板	∞	1.000	1.53	64.1
7		∞	5.000		
8	絞り	∞	0.000		
9	対物レ	1.247	2.750	1.525	56.5
10	ンズ	-0.861	0.330		
11	透明基	∞	0.100	1.619	30.0
12	板	∞			

非球面係数

第2面	κ	1.1783E+00
	A4	-1.1418E-03
	A6	6.7870E-04
	A8	4.4073E-05
	A10	-2.4035E-06

第10面	κ	-2.7384E+01
	A4	1.3778E-01
	A6	-3.2832E-01
	A8	2.6291E-01
	A10	-7.8115E-02
	A12	-2.5227E-04

第9面	κ	-7.0271E-01
	A4	2.0793E-02
	A6	-2.5985E-03
	A8	4.9919E-03
	A10	-2.2786E-04
	A12	-9.5332E-04
	A14	4.6404E-05
	A16	1.7553E-04
	A18	2.1430E-05
	A20	-2.9990E-05

回折面係数

第1面	b2	-1.3000E-02
	b4	1.7652E-03
	b6	-5.5596E-04

第9面	b2	-4.9893E-03
	b4	-3.7597E-04

[0076] (Example 2)
[0077] Purple-blue color semiconductor laser with a wavelength of 405nm was used for the light source, and the lens of numerical aperture 0.85 was used with the two two groups configuration as an objective lens. By making both sides of the coupling lens of one group [one] into a diffraction side, the axial overtone aberration generated with an objective lens was amended. Fluctuation of the spherical aberration resulting from the error of protection thickness, the wavelength variation of laser light source **, etc. was amended with the refractive-index distribution adjustable component arranged between a coupling lens and an objective lens. The optical-path Fig. of an example 2 is shown in drawing 5 . Moreover, the lens data of an example 2 are shown in the next table 4.
[0078]
[Table 4]

実施例2

面番号		r(mm)	d(mm)	Nλ	νd
0	光源		18.000		
1	カップリングレンズ	-25.624	1.200	1.525	56.5
2		-18.149	10.000		
3	偏光板	∞	2.000	1.53	64.1
4	基板	∞	1.000	1.53	64.1
5	液晶	∞	0.800	1.53	*
6	基板	∞	1.000	1.53	64.1
7		∞	2.000		
8	絞り	∞	0.000		
9	対物レンズ	2.074	2.400	1.525	56.5
10		8.053	0.100		
11		0.863	1.100	1.525	56.5
12		∞	0.240		
13	透明基板	∞	0.100	1.619	30.0
14		∞			

第9面	κ	-1.2955E-01
	A_4	-3.7832E-03
	A_6	5.1667E-04
	A_8	-1.1780E-03
	A_{10}	-2.0628E-04
	A_{12}	2.5941E-05
	A_{14}	1.4917E-04
	A_{16}	-5.1578E-05

第10面	κ	4.7554E+01
	A_4	1.3641E-02
	A_6	-2.9201E-02
	A_8	-9.3339E-03
	A_{10}	3.3011E-02
	A_{12}	-2.2626E-02

第11面	κ	-7.1425E-01
	A_4	1.3647E-01
	A_6	-5.3414E-02
	A_8	3.0269E-01
	A_{10}	-1.6898E-01

回折面係数

第1面	b_2	-1.1545E-02
	b_4	-2.1408E-05

第2面	b_2	-1.0955E-02
	b_4	1.0713E-05

[0079] (Example 3)
[0080] Purple-blue color semiconductor laser with a wavelength of 405nm was used for the light source, and the lens of numerical aperture 0.85 was used with the two two groups configuration as an objective lens. The coupling lens of a two two groups configuration consists of forward and a negative cemented lens, and amended the axial overtone aberration generated with an objective lens. Fluctuation of the spherical aberration resulting from the error of protection thickness, the wavelength variation of laser light source **, etc. was amended with the refractive-index distribution adjustable component arranged between a coupling lens and an objective lens. The optical-path Fig. of an example 3 is shown in drawing 6 . Moreover, the lens data of an example 3 are shown in the next table 5.
[0081]
[Table 5]

実施例3

面番号		r(mm)	d(mm)	Nλ	νd
0	光源		18.800		
1	カップリングレンズ	8.642	2.240	1.752	54.7
2		-4.629	1.420	1.914	23.8
3		3290.994	10.000		
4	偏光板	∞	2.000	1.53	64.1
5	基板	∞	1.000	1.53	64.1
6	液晶	∞	0.800	1.53	*
7	基板	∞	1.000	1.53	64.1
8		∞	5.000		
9	絞り	∞	0.000		
10	対物レンズ	2.074	2.400	1.525	56.5
11		8.053	0.100		
12		0.863	1.100	1.525	56.5
13		∞	0.240		
14	透明基板	∞	0.100	1.619	30.0
15		∞			

第10面		
	κ	-1.2955E-01
	A4	-3.7832E-03
	A6	5.1667E-04
	A8	-1.1780E-03
	A10	-2.0628E-04
	A12	2.5941E-05
	A14	1.4917E-04
	A16	-5.1578E-05

第11面		
	κ	4.7554E+01
	A4	1.3641E-02
	A6	-2.9201E-02
	A8	-9.3339E-03
	A10	3.3011E-02
	A12	-2.2626E-02

第12面		
	κ	-7.1425E-01
	A4	1.3647E-01
	A6	-5.3414E-02
	A8	3.0269E-01
	A10	-1.6898E-01

[0082] (Example 4)
[0083] Purple-blue color semiconductor laser with a wavelength of 405nm was used for the light source, and the lens of numerical aperture 0.85 was used with the one one group configuration as an objective lens. By making both sides of the coupling lens of one group [one] into a diffraction side, the axial overtone aberration generated with an objective lens was amended. Fluctuation of the spherical aberration resulting from the error of protection thickness, the wavelength variation of laser light source **, etc. was amended with the refractive-index distribution adjustable component arranged between a coupling lens and an objective lens. The optical-path Fig. of an example 4 is shown in drawing 7 . Moreover, the lens data of an example 3 are shown in the next table 6.
[0084]
[Table 6]

実施例4

面番号		r(mm)	d(mm)	Nλ	νd
0	光源		17.900		
1	カップリングレンズ	-15.542	1.200	1.525	56.5
2		-18.813	9.000		
3	偏光板	∞	2.000	1.53	64.1
4	基板	∞	1.000	1.53	64.1
5	液晶	∞	0.800	1.53	*
6	基板	∞	1.000	1.53	64.1
7		∞	6.355		
8	絞り	∞	0.000		
9	対物レンズ	1.194	2.650	1.525	56.5
10		-0.975	0.355		
11	透明基板	∞	0.100	1.619	30.0
12		∞			

非球面係数

第9面	κ	-6.8335E-01
	A_4	1.6203E-02
	A_6	1.5491E-03
	A_8	2.8929E-03
	A_{10}	-3.6771E-04
	A_{12}	-3.5822E-04
	A_{14}	1.4842E-04
	A_{16}	1.1960E-04
	A_{18}	-3.0230E-05
	A_{20}	-1.1052E-05

第10面	κ	-2.1704E+01
	A_4	3.0802E-01
	A_6	-6.3950E-01
	A_8	5.8536E-01
	A_{10}	-2.1562E-01
	A_{12}	-2.5227E-04

回折面係数

第1面	b_2	-1.4664E-02
	b_4	-6.3363E-05

第2面	b_2	-1.4839E-02
	b_4	2.7506E-05

[0085] In addition, in an above-mentioned table or above-mentioned drawing, E (or e) may be used for the expression of the exponentiation of 10, for example, it may express like E-02 (= 10-2).

[0086]

[Effect of the Invention] According to this invention, the optical system for optical pickups, the optical pickup equipment, and the record and the regenerative apparatus which can amend effectively the axial overtone aberration which originates in the mode hop phenomenon of a laser light source or RF superposition, and is generated with an objective lens can be offered.

[0087] Moreover, optical pickup equipment, and record and a regenerative apparatus equipped with the refractive-index part good light variation study component which can amend effectively fluctuation of the spherical aberration which originates in the error of the thickness of the protective layer of oscillation wavelength change of a laser light source, temperature and humidity, and an optical information record medium etc., and is generated in each optical surface of optical pickup equipment with a simple configuration can be offered.

[Translation done.]

TECHNICAL FIELD

[Field of the Invention] This invention relates to the optical system for optical pickups for record of the information on an optical information record medium, and/or playback, optical pickup equipment, and the record and the regenerative apparatus containing this optical pickup equipment.

[Translation done.]

PRIOR ART

[Description of the Prior Art] If short-wavelength-izing of a laser light source and high numerical-aperture-ization of an objective lens are attained, in the optical pickup equipment which consists of combination of a laser light source of long wavelength and an objective lens of a low numerical aperture which perform informational record or playback to the conventional optical disk like CD or DVD comparatively, being actualized more will be expected also on the almost disregarded problem.
[0003] One of them is the problem of the axial overtone aberration produced in an objective lens by fluctuation of the very small oscillation wavelength of a laser light source. The refractive-index change by the very small wavelength variation of a common optical lens ingredient becomes so large that short wavelength is dealt with. Therefore, for time, the depth of focus of an objective lens is [. to which the amount of defocusing of the focus produced by very small wavelength variation becomes large, and] k-lambda. The depth of focus becomes small and few amounts of defocusing are not allowed, either, so that it may understand from being expressed with /NA2 (wavelength and NA being [k] the image side numerical aperture of an objective lens for a proportionality constant and lambda) and operating wavelength is short. Therefore, in the optical system using the light source and the objective lens of high numerical aperture of short wavelength like purple-blue color semiconductor laser, in order to prevent degradation of the mode hop phenomenon of semiconductor laser, the wavelength variation by output change, and the wave aberration by RF superposition, amendment of axial overtone aberration becomes important.
[0004] Furthermore, another problem actualized in short-wavelength-izing of a laser light source and a raise in the numerical aperture of an objective lens is fluctuation of the spherical aberration of the optical system by temperature and humidity. That is, the plastic lens currently generally used in optical pickup equipment is easy to deform in response to temperature or humidity, and a refractive index changes a lot. In the optical system used for conventional optical pickup equipment, fluctuation of the spherical aberration by refractive-index change it was so much changeless on a problem also serves as an amount which cannot be disregarded in short-wavelength-izing of a laser light source, and a raise in the numerical aperture of an objective lens.
[0005] Furthermore, another problem actualized in short-wavelength-izing of a laser light source and a raise in the numerical aperture of an objective lens is fluctuation of the spherical aberration of the optical system resulting from the thickness error of the protective layer (it is also called a transparence substrate) of an optical disk. Generating the spherical aberration produced according to the thickness error of a protective layer in proportion to the 4th power of the numerical aperture of an objective lens is known. Therefore, there is a possibility that the effect of the thickness error of a protective layer may become large, and record or playback of the stable information may become impossible as the numerical aperture of an objective lens becomes large.
[0006] Moving mechanically spacing of the coupling lens and said objective lens for changing the angle of divergence of the emission light by which outgoing radiation was carried out from the light source as the technique of amending fluctuation of the spherical aberration generated in the

above reasons, and carrying out incidence to an objective lens, amending spherical aberration, and connecting a spot on the information recording surface of an optical information record medium has been performed.

[0007] However, it is disadvantageous for lightweight-izing of optical pickup equipment, and a cost cut to move the whole lens system or a part, and it is desirable that the above-mentioned spherical aberration etc. can be amended without moving a lens system.

[Translation done.]

EFFECT OF THE INVENTION

[Effect of the Invention] According to this invention, the optical system for optical pickups, the optical pickup equipment, and the record and the regenerative apparatus which can amend effectively the axial overtone aberration which originates in the mode hop phenomenon of a laser light source or RF superposition, and is generated with an objective lens can be offered.
[0087] Moreover, optical pickup equipment, and record and a regenerative apparatus equipped with the refractive-index part good light variation study component which can amend effectively fluctuation of the spherical aberration which originates in the error of the thickness of the protective layer of oscillation wavelength change of a laser light source, temperature and humidity, and an optical information record medium etc., and is generated in each optical surface of optical pickup equipment with a simple configuration can be offered.

[Translation done.]

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] This invention aims at offering the optical system for optical pickups, the optical pickup equipment, and the record and the regenerative apparatus which can amend effectively the axial overtone aberration which originates in the mode hop phenomenon of a laser light source, or RF superposition, and is generated with an objective lens.
[0009] Moreover, it aims at offering optical pickup equipment, and record and a regenerative apparatus equipped with the refractive-index part good light variation study component which can amend effectively fluctuation of the spherical aberration which originates in the error of the thickness of the protective layer of oscillation wavelength change of a laser light source, temperature and humidity, and an optical information record medium etc., and is generated in each optical surface of optical pickup equipment with a simple configuration.

[Translation done.]

MEANS

[Means for Solving the Problem] In order to attain the above-mentioned purpose, the optical system for optical pickups by this invention changes the angle of divergence of the emission light to which outgoing radiation of the wavelength lambda was carried out from the light source 500nm or less, is equipped with the condensing optical system containing the coupling lens and objective lens for carrying out incidence to an objective lens, and is characterized by having a diffraction side in the 2nd [at least / or more] page of said condensing optical system.
[0011] According to this optical system for optical pickups, by changing the angle of divergence of the emission light to which outgoing radiation of the wavelength lambda was carried out from the light source 500nm or less, and having a diffraction side in the 2nd [at least / or more] page of the condensing optical system containing the coupling lens and objective lens for carrying out incidence to an objective lens, the diameter of a spot can be made small and axial overtone aberration can be amended good.
[0012] Moreover, the 1st optical pickup equipment by this invention changes the angle of divergence of the emission light to which outgoing radiation of the wavelength lambda was carried out from the light source 500nm or less, is equipped with the condensing optical system containing the coupling lens and objective lens for carrying out incidence to an objective lens, and is characterized by having a diffraction side in the 2nd [at least / or more] page of said condensing optical system.
[0013] According to this optical pickup equipment, by changing the angle of divergence of the emission light to which outgoing radiation of the wavelength lambda was carried out from the light source 500nm or less, and having a diffraction side in the 2nd [at least / or more] page of the condensing optical system containing the coupling lens and objective lens for carrying out incidence to an objective lens, the diameter of a spot can be made small and axial overtone aberration can be amended good.
[0014] Moreover, the 2nd optical pickup equipment by this invention The objective lens which condenses the flux of light from the light source to the information recording surface of an optical information record medium, The coupling lens for changing the angle of divergence of the emission light by which outgoing radiation was carried out from said light source, and carrying out incidence to said objective lens, The refractive-index distribution adjustable component which can amend the spherical aberration produced in each optical surface by being arranged between said light sources and said objective lenses, and changing refractive-index distribution, It has a diffraction side in the 1st [at least] page of a preparation, said coupling lens, said refractive-index distribution adjustable component, and said objective lens, and is characterized by carrying out offset amendment of the axial overtone aberration generated in optical elements other than said objective lens according to said axial overtone aberration which occurs in respect of diffraction.
[0015] By changing refractive-index distribution with the refractive-index distribution adjustable component arranged between the coupling lens for according to this optical pickup equipment changing the angle of divergence of the emission light by which outgoing radiation was carried out from the light source, and carrying out incidence to an objective lens, and an objective lens Amendment can do spherical aberration produced in each optical surface, and the axial overtone

aberration which was prepared in the 1st [at least] page of the equipment of a coupling lens, a refractive-index distribution adjustable component, and an objective lens and which is generated in optical elements other than a diffraction lens in respect of diffraction can be amended good.
[0016] Moreover, in the 2nd optical pickup equipment, when change of the focal location of the synthetic system of said coupling lens and said objective lens when +10nm of wavelength of said light source changes is set to deltafB (micrometer) and image side numerical aperture of said objective lens is set to NAobj, it is desirable that the axial overtone aberration of said synthetic system fills a degree type (1).
[0017]
| deltafB and (NAobj) 2|<=2.5micrometer (1)
[0018] Moreover, the 3rd optical pickup equipment by this invention The light source and the color correction optical element by which axial overtone aberration was superfluously amended to wavelength shorter 10nm than the criteria wavelength of said light source, By being arranged between the objective lens which condenses the flux of light from said light source to the information recording surface of an optical information record medium, and said light source and said objective lens, and changing refractive-index distribution It has the refractive-index distribution adjustable component which can amend the spherical aberration produced in each optical surface, and said color correction optical element is characterized by carrying out offset amendment of the axial overtone aberration generated with said objective lens and said refractive-index distribution adjustable component.
[0019] With this optical pickup equipment, the axial overtone aberration generated with the refractive-index distribution adjustable component which amends the wave aberration produced in each optical surface, and an objective lens can be offset by the color correction optical element.
[0020] Moreover, the angle of divergence of the emission light to which outgoing radiation of said color correction optical element was carried out from said light source in the 3rd optical pickup equipment is changed. Are a coupling lens for carrying out incidence to an objective lens, and change of the focal location of the synthetic system of said coupling lens and said objective lens when +10nm of wavelength of said light source changes is set to deltafB (micrometer). When image side numerical aperture of said objective lens is set to NAobj, it is desirable that the axial overtone aberration of said synthetic system fills a degree type (2).
[0021]
| deltafB and (NAobj) 2|<=2.5micrometer (2)
[0022] Moreover, when the ingredient of said refractive-index distribution adjustable component divides and impresses electric field, a magnetic field, or temperature to this liquid crystal on the zona orbicularis including liquid crystal in the 2nd or 3rd optical pickup equipment, it is desirable to change refractive-index distribution. Thus, by dividing and impressing electric field, a magnetic field, or temperature to the liquid crystal of the ingredient of a refractive-index distribution adjustable component on the zona orbicularis, refractive-index distribution almost symmetrical with a core can be formed to the optical axis of optical system, and aberration, such as spherical aberration generated except a refractive-index distribution adjustable component, can be amended.
[0023] In the 2nd or 3rd optical pickup equipment moreover, said refractive-index distribution adjustable component The laminating of a transparent electrode layer and the opto electronics material layer is carried out by turns, and the layer of the arbitration of said transparent electrode layers is divided on the zona orbicularis. When the transparence conductive layer divided in the shape of [the] zona orbicularis functions as two or more electrodes and controls electrically the refractive index of said opto electronics material layer using said two or more electrodes, it is desirable to change refractive-index distribution. By changing refractive-index distribution by such control, refractive-index distribution almost symmetrical with a core can be formed to the optical axis of optical system, and aberration, such as spherical aberration generated except a refractive-index distribution adjustable component, can be amended.
[0024] Moreover, the Abbe number of said refractive-index distribution adjustable component can amend the spherical aberration generated from other optical elements, such as an objective

lens, good by satisfying a degree type (3).
[0025] 80>nud> 10 (3)
[0026] Moreover, by applying a constant voltage near the field at which said refractive-index distribution adjustable component crosses an optical axis, the distribution to which a refractive index becomes small, or its reverse distribution can be easily formed, so that a refractive-index distribution adjustable component approaches the field at which an optical axis is crossed.
[0027] Moreover, when at least one field of said color correction optical element is the coupling lens which has diffraction structure, the offset amendment of the axial overtone aberration generated in other optical elements, such as an objective lens, can be carried out good.
[0028] Moreover, diffraction structure and the aspheric surface can be added easily, and it can mass-produce by said coupling lens being formed from plastic material cheaply.
[0029] Moreover, when maximum of the height of a MAJINARU beam of light is set to hm, as for said diffraction side, it is desirable to be prepared in the field with which height h of a MAJINARU beam of light fills a degree type (4).
[0030]
0.5 hm<h<=hm (4)
[0031] By making it fill an above-mentioned formula (4), since the zona-orbicularis pitch in the MAJINARU beam-of-light height of a diffraction lens can be enlarged, decline in the efficiency for light utilization by the blaze configuration error can be suppressed. For example, when approximated by the light-gage lens model, the axial overtone aberration of optical system is expressed with the several 1 following formula.
[0032]
[Equation 1]

$$\delta s'_\alpha = -\left(\frac{s'_\alpha}{h_1}\right)^2 \sum_{j=1}^{\alpha} \frac{\phi_j h_j^2}{\nu_j}$$

S'α ：最終レンズからガウス像面までの距離

Here, phij (j= 1, 2 and 3, —, alpha) is the refractive power of each thin lens, hj (j= 1, 2 and 3, —, alpha) is the height from the optical axis of the MAJINARU beam of light which passes along each thin lens, and nuj (j= 1, 2 and 3, —, alpha) is the Abbe number of each lens.
[0033] Here, a diffraction side is established in the k-th lens, and a part of the refractive power is given to a diffraction side. If the refractive power by diffraction is expressed as phid, the refractive power of the k-th lens will be permuted by phik=(phik-phid)+phid, and I make refractive-power phid according (phik-phid) to refraction into the refractive power by diffraction, and think that those lenses stick and it is arranged. At this time, the Abbe number of the part of (phik-phid) is set to nuk, and the Abbe number of phid writes nud as the Abbe number of a diffraction side. If this formula is substituted for several 1 above-mentioned formula and the following achromatic condition is used, the several 2 following formula will be drawn.
[0034]
[Equation 2]

$$\sum_{j=1}^{\alpha} \frac{\phi_j h_j^2}{\nu_j} + \left(\frac{1}{\nu_d} - \frac{1}{\nu_k}\right)\phi_d h_k^2 = 0$$

色消し条件 δ S'α ＝0

Therefore, refractive-power phid of a diffraction side required for achromatism can be expressed with the several 3 following formula.
[0035]
[Equation 3]

$$\phi_d = \left(\sum_{j=1}^{\alpha} \frac{\phi_j h_j^2}{\nu_j}\right) \Bigg/ \left(\frac{1}{\nu_k} - \frac{1}{\nu_d}\right) h_k^2 = \frac{C}{h_k^2}$$

Here, C in several 3 above-mentioned formula can be expressed with the several 4 following formula.
[0036]
[Equation 4]

$$C = \left(\sum_{j=1}^{\alpha} \frac{\phi_j h_j^2}{\nu_j}\right) \Bigg/ \left(\frac{1}{\nu_k} - \frac{1}{\nu_d}\right)$$

On the other hand, since the optical-path-difference function of a diffraction side is almost the 2nd order because of achromatism, an optical-path-difference function can be expressed with the several 5 following formula when phid is used.
[0037]
[Equation 5]

$$\Phi(h) = \frac{1}{2}\phi_d h^2$$

The zona-orbicularis pitch in the height hk of a MAJINARU beam of light when the shape of zona orbicularis blaze-izes this diffraction side at this time will serve as the several 6 following formula, if several 3 above-mentioned formula is used.
[0038]
[Equation 6]

$$P(h_k) = \frac{m\lambda}{\frac{d\Phi}{dh}} = \frac{m\lambda h_k}{C}$$

This several 6 formula shows that the height of a MAJINARU beam of light, i.e., the zona-orbicularis pitch in the maximum circumference part of the effective diameter of each lens, is proportional to that beam-of-light height. Therefore, as for a zona-orbicularis pitch, the direction where MAJINARU beam-of-light quantity arranges a diffraction side to a high field becomes large. Decline in the diffraction efficiency by the blaze configuration error of each zona orbicularis occurs, so that a zona-orbicularis pitch is large, and it is a difficulty pile.
[0039] Moreover, a cost cut and lightweight-izing of optical pickup equipment can be attained

because said objective lens consists of one sheet.
[0040] Moreover, when thickness on the optical axis of said objective lens is set to d and a focal distance is set to f, it is desirable to fill a degree type (5) and (6). They are conditions for a formula (6) and NA to acquire a good image quantity property in a larger single ball lens than 0.70.
[0041]
0.98>NA>0.7 (5)
0.81<d/f<3.0 (6)
[0042] Moreover, when said objective lens fills a degree type (7), the axial overtone aberration of a synthetic system can be amended good.
[0043]
0.02< sigmaphichro/phi obj<0.30 (7)
Here, sigmaphichro is the sum of the power of a diffraction lens side, and is phiobj. The power of an objective lens is shown.
[0044] Moreover, the axial overtone aberration of a synthetic system can be amended good by said objective lens consisting of two sheets.
[0045] The axial overtone aberration of a synthetic system can be amended good because said objective lens fills a degree type (8).
[0046]
0.02< sigmaphichro/phi obj<0.25 (8)
Here, sigmaphichro is the sum of the power of a diffraction lens side, and phiobj shows the power of an objective lens.
[0047] Moreover, the offset amendment of the axial overtone aberration generated by other optical elements, such as an objective lens, because said coupling lens consists of forward and a two negative lens can be carried out good.
[0048] Moreover, if it is made for the Abbe number of said coupling lens to fill a degree type (9) and (10), respectively, the coupling lens of the still better engine performance can be obtained.
[0049] nudP> 40.0 (9)
[0050] nudN<60.0 (10)
However, Abbe-number nudN of d line of a nudP:positive lens: The Abbe number of d line of a negative lens [0051] Moreover, it is desirable for said objective lens to consist of one lens, and to set thickness on the optical axis of said lens to d, it to set a focal distance to f, and to fill a degree type. Formulas (12) are conditions for NA to acquire a good image quantity property in a larger single ball lens than 0.70.
[0052]
0.98>NA>0.7 (11)
0.81<d/f<3.0 (12)
[0053] Moreover, the axial overtone aberration of a synthetic system can be amended good by said objective lens consisting of two lenses.
[0054] Moreover, it is desirable to have further the optical-path division component which is arranged between said light source and said refractive-index distribution adjustable component, and carries out the monitor of the condition of the wave aberration in an image formation side. When a monitor etc. carries out the condition of the wave aberration in an image formation side with an optical-path division component, a spot can be connected good on an information recording surface to change of the information recording surface cover layer thickness of for example, an optical information record medium by changing refractive-index distribution of a refractive-index distribution adjustable component from the information on the wave aberration of an image formation side.
[0055] Moreover, the record and the regenerative apparatus by this invention carry above-mentioned optical pickup equipment, and performs playback of record of voice and/or an image, voice, and/or an image.
[0056] Since according to this record and regenerative apparatus the axial overtone aberration which originates in the mode hop phenomenon of a laser light source or RF superposition, and is generated with an objective lens is amended effectively and fluctuation of the spherical

aberration which originates in the error of the thickness of the protective layer of oscillation wavelength change of a laser light source, temperature and humidity, and an optical information record medium etc., and is generated in each optical surface can be amended effectively, record and playback can be performed stably and correctly.
[0057]
[Embodiment of the Invention] Hereafter, the gestalt of operation by this invention is explained using a drawing. Drawing 1 is drawing showing roughly the optical system for optical pickups by the gestalt of operation of this invention, and optical pickup equipment.
[0058] With the optical pickup equipment (optical system for optical pickups) shown in drawing 1 , the flux of light from the laser light source 1 whose wavelength lambda is about 400nm passes the coupling lens 2, the prism pair 3, the deviation beam splitter 4, the refractive-index distribution adjustable component 5, and diaphragm 6, and is condensed by the information recording surface 9 through protective layer 9' of an optical information record medium with an objective lens 7. It is reflected by the deviation beam splitter 4 and the reflected light from the information recording surface 9 goes to the photodetector system 10, after passing an objective lens 7 and refractive-index distribution adjustable component 5 grade. An objective lens 7 is driven in the direction of focusing, and the direction of tracking with the biaxial actuator 8.
[0059] Moreover, although the optical pickup equipment of drawing 1 is not illustrated, it detects fluctuation of the spherical aberration generated according to condensing optical system by detecting the reflected light from the information recording surface 9, and has a spherical-aberration detection means to generate a spherical-aberration error signal based on the detection result. The refractive-index distribution adjustable component as a spherical-aberration amendment means is made to drive so that a spherical-aberration error signal may become zero. What is indicated by the application for patent No. 108378 [2001 to] by the same applicant, for example as the spherical-aberration detection approach in such a spherical-aberration detection means and a spherical-aberration detection means can be used. In addition, an above-mentioned spherical-aberration detection means is arranged in the optical path between a spherical-aberration amendment means and the light source.
[0060] Moreover, the refractive-index distribution adjustable component 5 is arranged between the coupling lens 2 and an objective lens 7, and amends fluctuation of the spherical aberration which originates in the error of the thickness of protective layer 9' of oscillation wavelength change of a laser light source 1, temperature and humidity, and an optical information record medium etc., and is generated in each optical surface. That is, when spherical aberration is changed in the condensing optical system of drawing 1 , fluctuation of this spherical aberration is detected by the photodetector system 10, and based on this detected spherical-aberration error signal, driving means 5a drives the refractive-index distribution adjustable component 5, and amends spherical aberration.
[0061] Next, drawing 2 and drawing 3 explain the example of the refractive-index distribution adjustable component 5 of drawing 1 .
[0062] The laminating of the refractive-index distribution adjustable components d and e from which refractive-index distribution changes according to the electrical potential difference which it connects electrically, and the refractive-index adjustable component shown in drawing 2 is electrically insulated to the transparent electrode layers a, b, and c and the electrode layers a, b, and c optically, and is impressed from a driving means A is carried out by turns, they are formed, and the electrode layers a, b, and c are divided into the shape of zona orbicularis to two or more fields.
[0063] With the refractive-index adjustable component of drawing 2 , the seal of approval of the electrical potential difference is carried out to the electrode layers a, b, and c of the shape of two or more zona orbicularis from a driving means A, and aberration, such as spherical aberration which can form refractive-index distribution almost symmetrical with a core to the optical axis of optical system by driving the refractive-index distribution adjustable components d and e, and is generated except a refractive-index distribution adjustable component, can be amended.
[0064] The closure of the liquid crystal 1i is carried out by the seal members 1g and 1h, and the refractive-index adjustable component shown in drawing 3 is pinched among the transparence

substrates 1a and 1b which formed the transparent electrode layers 1c and 1d. The orientation film 1e and 1f is formed inside the transparence substrates 1a and 1b, and the transparent electrode layers 1c and 1d are divided into plurality in the shape of zona orbicularis. By changing the refractive index of liquid crystal i from a driving means A in the shape of zona orbicularis according to the electrical potential difference by which a seal of approval is carried out, aberration, such as spherical aberration generated except a refractive-index distribution adjustable component, can be amended.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is drawing showing roughly the optical system for optical pickups by the gestalt of operation of this invention, and optical pickup equipment.
[Drawing 2] It is drawing showing the refractive-index adjustable component as an example of the refractive-index distribution adjustable component of drawing 1 .
[Drawing 3] It is drawing showing the refractive-index adjustable component as another example of the refractive-index distribution adjustable component of drawing 1 .
[Drawing 4] It is an optical-path Fig. about an example 1.
[Drawing 5] It is an optical-path Fig. about an example 2.
[Drawing 6] It is an optical-path Fig. about an example 3.
[Drawing 7] It is an optical-path Fig. about an example 4.
[Description of Notations]
1 Laser Light Source
2 Coupling Lens
5 Refractive-Index Distribution Adjustable Component
7 Objective Lens
9 Information Recording Surface of Optical Information Record Medium
9' Protective layer of an optical information record medium
10 Photodetector System

[Translation done.]

EXAMPLE

[Example] Next, examples 1-4 explain this invention still more concretely. A list of the data about the coupling lens in each examples 1-4, an objective lens, and a synthetic system is shown in the next table 1.
[0066]
[Table 1]

実施例1

使用波長 λ (nm)		405
カップリングレンズ	レンズ枚数	1
	回折面数	1
対物レンズ	レンズ枚数	1
	回折面数	1
	NA	0.85
	d/f	1.56
合成系	回折面数	2
	h1/hm	0.95
	h2/hm	1.00
	$\lvert\Delta fb\rvert$ (μm)	1.01
	$\lvert\Delta fb\cdot(NA_{obj})^2\rvert$ (μm)	0.73
	$\Sigma\phi_{doe}/\phi_{obj}$	6.34E-02

実施例2

使用波長 λ (nm)		405
カップリングレンズ	レンズ枚数	1
	回折面数	2
対物レンズ	レンズ枚数	2
	回折面数	0
	NA	0.85
合成系	回折面数	2
	h1/hm	0.98
	h2/hm	1.00
	$\lvert\Delta fb\rvert$ (μm)	0.19
	$\lvert\Delta fb\cdot(NA_{obj})^2\rvert$ (μm)	0.14
	$\Sigma\phi_{doe}/\phi_{obj}$	7.94E-02

実施例3

使用波長 λ (nm)		405
カップリングレンズ	レンズ枚数	2
	回折面数	0
	νdP	54.7
	νdN	23.8
対物レンズ	レンズ枚数	2
	回折面数	0
	NA	0.85
合成系	回折面数	0
	$\lvert\Delta fb\rvert$ (μm)	0.03
	$\lvert\Delta fb\cdot(NA_{obj})^2\rvert$ (μm)	0.02

実施例4

使用波長 λ (nm)		405
カップリングレンズ	レンズ枚数	1
	回折面数	2
対物レンズ	レンズ枚数	1
	回折面数	0
	NA	0.85
	d/f	1.50
合成系	回折面数	2
	h1/hm	0.85
	h2/hm	1.00
	$\lvert\Delta fb\rvert$ (μm)	1.29
	$\lvert\Delta fb\cdot(NA_{obj})^2\rvert$ (μm)	0.83
	$\Sigma\phi_{doe}/\phi_{obj}$	1.04E-01

※ここでh1、h2は回折レンズ面を通過するマージナル光線の高さである。

[0067] Moreover, the wave aberration data amendment before by the refractive-index distribution component in each examples 1-4 and after amendment are shown in the next table 2.
[0068]

[Table 2]

実施例1 (単玉) 回折面2面

球面収差変動の要因		補正前の波面収差	補正後の波面収差	屈折率分布
基準状態		0.008λ	0.008λ	
LDの波長変動	Δλ=+10nm	0.066λ	0.008λ	$n(R)=n_0(\lambda)-0.6084e{-}6R^4$
	Δλ=-10nm	0.077λ	0.011λ	$n(R)=n_0(\lambda)+0.8007e{-}5R^4$
温度変化	ΔT=+30℃	0.073λ	0.008λ	$n(R)=n_0(\lambda)+0.7138e{-}5R^4$
	ΔT=-30℃	0.076λ	0.01λ	$n(R)=n_0(\lambda)+0.1726e{-}3R^4$
透明基板厚さ誤差	Δt=+0.02mm	0.195λ	0.008λ	$n(R)=n_0(\lambda)+0.3432e{-}4R^4$
	Δt=-0.02mm	0.188λ	0.008λ	$n(R)=n_0(\lambda)+0.4451e{-}3R^4$

実施例2 回折コリ+2枚対物

球面収差変動の要因		補正前の波面収差	補正後の波面収差	屈折率分布
基準状態		0.004λ	0.004λ	
LDの波長変動	Δλ=+10nm	0.056λ	0.005λ	$n(R)=n_0(\lambda)-0.6540e{-}5R^4-0.2711e{-}4R^6$
	Δλ=-10nm	0.063λ	0.008λ	$n(R)=n_0(\lambda)-0.2808e{-}4R^4+0.3635e{-}4R^6$
温度変化	ΔT=+30℃	0.014λ	0.004λ	$n(R)=n_0(\lambda)-0.1048e{-}3R^4-0.2338e{-}4R^6$
	ΔT=-30℃	0.014λ	0.004λ	$n(R)=n_0(\lambda)-0.1085e{-}3R^4+0.2680e{-}4R^6$
透明基板厚さ誤差	Δt=+0.02mm	0.184λ	0.009λ	$n(R)=n_0(\lambda)-0.1839e{-}4R^4-0.8407e{-}4R^6$
	Δt=-0.02mm	0.201λ	0.010λ	$n(R)=n_0(\lambda)-0.4350e{-}4R^4+0.1086e{-}3R^6$

実施例3 2枚コリ+2枚対物

球面収差変動の要因		補正前の波面収差	補正後の波面収差	屈折率分布
基準状態		0.008λ	0.006λ	
LDの波長変動	Δλ=+10nm	0.038λ	0.004λ	$n(R)=n_0(\lambda)+0.5831e{-}4R^4-0.3160e{-}4R^6$
	Δλ=-10nm	0.056λ	0.008λ	$n(R)=n_0(\lambda)-0.2277e{-}5R^4+0.2785e{-}4R^6$
温度変化	ΔT=+30℃	0.018λ	0.015λ	$n(R)=n_0(\lambda)+0.1764e{-}4R^4-0.1153e{-}5R^6$
	ΔT=-30℃	0.011λ	0.004λ	$n(R)=n_0(\lambda)-0.7082e{-}4R^4+0.1908e{-}4R^6$
透明基板厚さ誤差	Δt=+0.02mm	0.197λ	0.006λ	$n(R)=n_0(\lambda)+0.5860e{-}5R^4-0.5651e{-}4R^6$
	Δt=-0.02mm	0.190λ	0.020λ	$n(R)=n_0(\lambda)-0.3127e{-}4R^4+0.1108e{-}3R^6$

実施例4 (単玉) 回折コリ+1枚対物

球面収差変動の要因		補正前の波面収差	補正後の波面収差	屈折率分布
基準状態		0.005λ	0.005λ	
LDの波長変動	Δλ=+10nm	0.142λ	0.007λ	$n(R)=n_0(\lambda)+0.1039e{-}6R^4-0.6275e{-}4R^6$
	Δλ=-10nm	0.148λ	0.017λ	$n(R)=n_0(\lambda)-0.8168e{-}4R^4+0.9883e{-}4R^6$
温度変化	ΔT=+30℃	0.164λ	0.008λ	$n(R)=n_0(\lambda)+0.4840e{-}4R^4-0.8308e{-}4R^6$
	ΔT=-30℃	0.154λ	0.007λ	$n(R)=n_0(\lambda)-0.2375e{-}2R^2-0.1539e{-}3R^4$
透明基板厚さ誤差	Δt=+0.02mm	0.199λ	0.007λ	$n(R)=n_0(\lambda)+0.1982e{-}2R^2$
	Δt=-0.02mm	0.190λ	0.009λ	$n(R)=n_0(\lambda)-0.1922e{-}2R^2$

※光軸をZ軸とすると $R^2=X^2+Y^2$

[0069] In addition, the aspheric surface in the lens of this example expresses [height] the radius of curvature of h and a refracting interface with the following several 7 for the direction of an optical axis, when setting the height of a direction perpendicular to the X-axis and an optical axis to r. However, let a circular-cone multiplier and A2i be aspheric surface multipliers for kappa.

[0070]

[Equation 7]

$$X=\frac{h^2/r}{1+\sqrt{1-(1+\kappa)h^2/r^2}}+\sum_{i=2}A_{2i}h^{2i}$$

[0071] Moreover, the following several 8 can express the diffraction side of the shape of zona orbicularis prepared in the lens of this example as optical-path-difference function phib. Here, h is height perpendicular to an optical axis, and b2i is the multiplier of an optical-path-difference function.

[0072]

[Equation 8]

$$\Phi_b=\sum_{i=1}b_{2i}h^{2i}$$

[0073] (Example 1)

[0074] In drawing 1 , purple-blue color semiconductor laser with a wavelength of 405nm was used for the light source, and the objective lens of numerical aperture 0.85 was used by one group [one]. Axial overtone aberration was amended by forming a diffraction side in the light source side of an objective lens the light source side of an one one group coupling lens, respectively. Moreover, the aberration of a synthetic system was delicately amended by making the field by the side of the optical information record medium of a coupling lens, and both sides of an objective lens into the aspheric surface. Fluctuation of the spherical aberration resulting

from the error of protection thickness, the wavelength variation of laser light source **, etc. was amended with the refractive-index distribution adjustable component arranged between a coupling lens and an objective lens. The optical-path Fig. of an example 1 is shown in drawing 4 . Moreover, the lens data of an example 1 are shown in the next table 3.
[0075]
[Table 3]

実施例1

面番号		r(mm)	d(mm)	Nλ	νd
0	光源		7.929		
1	カップリングレンズ	∞	1.000	1.525	56.5
2		-5.587	5.000		
3	偏光板	∞	2.000	1.53	64.1
4	基板	∞	1.000	1.53	64.1
5	液晶	∞	0.800	1.53	*
6	基板	∞	1.000	1.53	64.1
7		∞	5.000		
8	絞り	∞	0.000		
9	対物レンズ	1.247	2.750	1.525	56.5
10		-0.861	0.330		
11	透明基板	∞	0.100	1.619	30.0
12		∞			

非球面係数

第2面	κ	1.1783E+00
	A4	-1.1418E-03
	A6	6.7870E-04
	A8	4.4073E-05
	A10	-2.4035E-06

第10面	κ	-2.7384E+01
	A4	1.3778E-01
	A6	-3.2832E-01
	A8	2.6291E-01
	A10	-7.8115E-02
	A12	-2.5227E-04

第9面	κ	-7.0271E-01
	A4	2.0793E-02
	A6	-2.5985E-03
	A8	4.9919E-03
	A10	-2.2786E-04
	A12	-9.5332E-04
	A14	4.6404E-05
	A16	1.7553E-04
	A18	2.1430E-05
	A20	-2.9990E-05

回折面係数

第1面	b2	-1.3000E-02
	b4	1.7652E-03
	b6	-5.5596E-04

第9面	b2	-4.9893E-03
	b4	-3.7597E-04

[0076] (Example 2)
[0077] Purple-blue color semiconductor laser with a wavelength of 405nm was used for the light source, and the lens of numerical aperture 0.85 was used with the two two groups configuration as an objective lens. By making both sides of the coupling lens of one group [one] into a diffraction side, the axial overtone aberration generated with an objective lens was amended. Fluctuation of the spherical aberration resulting from the error of protection thickness, the wavelength variation of laser light source **, etc. was amended with the refractive-index distribution adjustable component arranged between a coupling lens and an objective lens. The optical-path Fig. of an example 2 is shown in drawing 5 . Moreover, the lens data of an example 2 are shown in the next table 4.
[0078]
[Table 4]

実施例2

面番号		r(mm)	d(mm)	Nλ	νd
0	光源		18.000		
1	カップリングレンズ	-25.624	1.200	1.525	56.5
2		-18.149	10.000		
3	偏光板	∞	2.000	1.53	64.1
4	基板	∞	1.000	1.53	64.1
5	液晶	∞	0.800	1.53	*
6	基板	∞	1.000	1.53	64.1
7		∞	2.000		
8	絞り	∞	0.000		
9	対物レンズ	2.074	2.400	1.525	56.5
10		8.053	0.100		
11		0.863	1.100	1.525	56.5
12		∞	0.240		
13	透明基板	∞	0.100	1.619	30.0
14		∞			

第9面	κ	-1.2955E-01
	A4	-3.7832E-03
	A6	5.1667E-04
	A8	-1.1780E-03
	A10	-2.0628E-04
	A12	2.5941E-05
	A14	1.4917E-04
	A16	-5.1578E-05

第10面	κ	4.7554E+01
	A4	1.3641E-02
	A6	-2.9201E-02
	A8	-9.3339E-03
	A10	3.3011E-02
	A12	-2.2626E-02

第11面	κ	-7.1425E-01
	A4	1.3647E-01
	A6	-5.3414E-02
	A8	3.0269E-01
	A10	-1.6898E-01

回折面係数

第1面	b2	-1.1545E-02
	b4	-2.1408E-05

第2面	b2	-1.0955E-02
	b4	1.0713E-05

[0079] (Example 3)
[0080] Purple-blue color semiconductor laser with a wavelength of 405nm was used for the light source, and the lens of numerical aperture 0.85 was used with the two two groups configuration as an objective lens. The coupling lens of a two two groups configuration consists of forward and a negative cemented lens, and amended the axial overtone aberration generated with an objective lens. Fluctuation of the spherical aberration resulting from the error of protection thickness, the wavelength variation of laser light source **, etc. was amended with the refractive-index distribution adjustable component arranged between a coupling lens and an objective lens. The optical-path Fig. of an example 3 is shown in drawing 6 . Moreover, the lens data of an example 3 are shown in the next table 5.
[0081]
[Table 5]

実施例3

面番号		r(mm)	d(mm)	Nλ	νd
0	光源		18.800		
1	カップ	8.642	2.240	1.752	54.7
2	リング	-4.629	1.420	1.914	23.8
3	レンズ	3290.994	10.000		
4	偏光板	∞	2.000	1.53	64.1
5	基板	∞	1.000	1.53	64.1
6	液晶	∞	0.800	1.53	*
7	基板	∞	1.000	1.53	64.1
8		∞	5.000		
9	絞り	∞	0.000		
10	対物レンズ	2.074	2.400	1.525	56.5
11		8.053	0.100		
12		0.863	1.100	1.525	56.5
13		∞	0.240		
14	透明基板	∞	0.100	1.619	30.0
15		∞			

第10面		
	κ	-1.2955E-01
	A4	-3.7832E-03
	A6	5.1667E-04
	A8	-1.1780E-03
	A10	-2.0628E-04
	A12	2.5941E-05
	A14	1.4917E-04
	A16	-5.1578E-05

第11面		
	κ	4.7554E+01
	A4	1.3641E-02
	A6	-2.9201E-02
	A8	-9.3339E-03
	A10	3.3011E-02
	A12	-2.2626E-02

第12面		
	κ	-7.1425E-01
	A4	1.3647E-01
	A6	-5.3414E-02
	A8	3.0269E-01
	A10	-1.6898E-01

[0082] (Example 4)

[0083] Purple-blue color semiconductor laser with a wavelength of 405nm was used for the light source, and the lens of numerical aperture 0.85 was used with the one one group configuration as an objective lens. By making both sides of the coupling lens of one group [one] into a diffraction side, the axial overtone aberration generated with an objective lens was amended. Fluctuation of the spherical aberration resulting from the error of protection thickness, the wavelength variation of laser light source **, etc. was amended with the refractive-index distribution adjustable component arranged between a coupling lens and an objective lens. The optical-path Fig. of an example 4 is shown in drawing 7 . Moreover, the lens data of an example 3 are shown in the next table 6.

[0084]

[Table 6]

実施例4

面番号		r(mm)	d(mm)	Nλ	νd
0	光源		17.900		
1	カップリングレンズ	-15.542	1.200	1.525	56.5
2		-18.813	9.000		
3	偏光板	∞	2.000	1.53	64.1
4	基板	∞	1.000	1.53	64.1
5	液晶	∞	0.800	1.53	*
6	基板	∞	1.000	1.53	64.1
7		∞	6.355		
8	絞り	∞	0.000		
9	対物レンズ	1.194	2.650	1.525	56.5
10		-0.975	0.355		
11	透明基板	∞	0.100	1.619	30.0
12		∞			

非球面係数

第9面	κ	-6.8335E-01
	A4	1.6203E-02
	A6	1.5491E-03
	A8	2.8929E-03
	A10	-3.6771E-04
	A12	-3.5822E-04
	A14	1.4842E-04
	A16	1.1960E-04
	A18	-3.0230E-05
	A20	-1.1052E-05

第10面	κ	-2.1704E+01
	A4	3.0802E-01
	A6	-6.3950E-01
	A8	5.8536E-01
	A10	-2.1562E-01
	A12	-2.5227E-04

回折面係数

第1面	b2	-1.4664E-02
	b4	-6.3363E-05

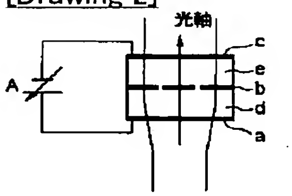
第2面	b2	-1.4839E-02
	b4	2.7506E-05

[0085] In addition, in an above-mentioned table or above-mentioned drawing, E (or e) may be used for the expression of the exponentiation of 10, for example, it may express like E-02 (= 10-2).

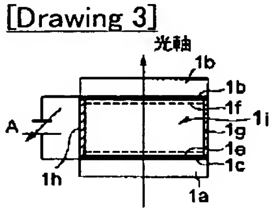
[Translation done.]

DRAWINGS

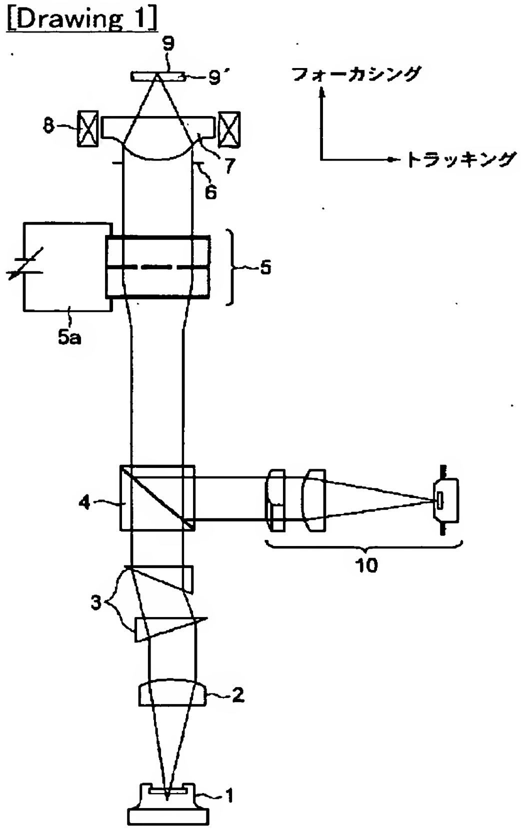
[Drawing 2]



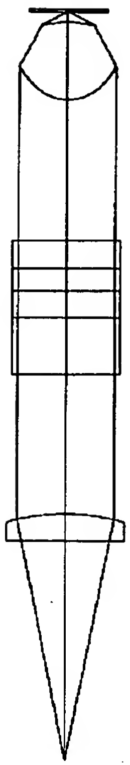
[Drawing 3]



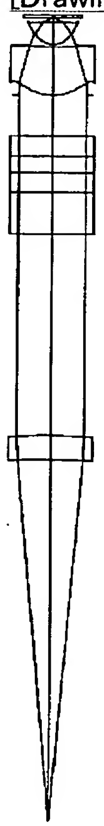
[Drawing 1]



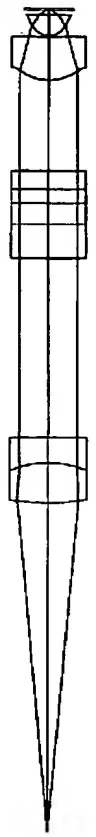
[Drawing 4]



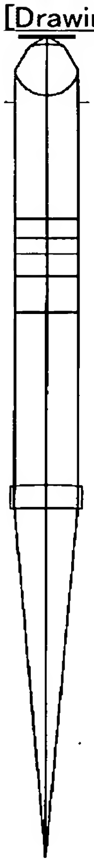
[Drawing 5]



[Drawing 6]



[Drawing 7]



[Translation done.]

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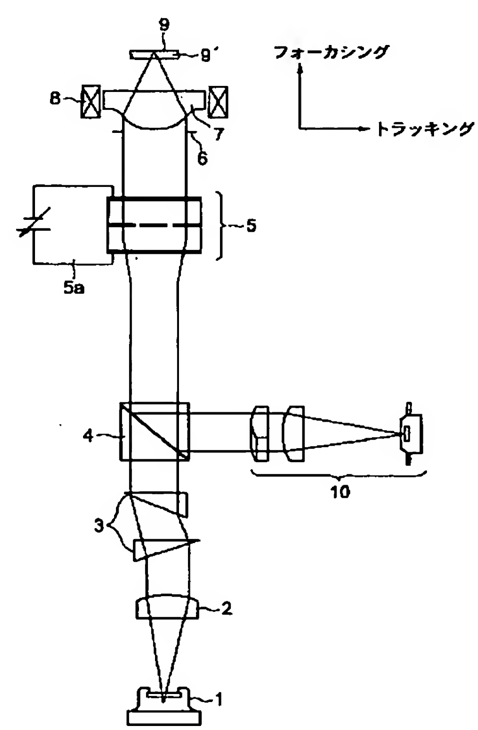
JA64 JB01 JB02 JB04

(54)【発明の名称】　光ピックアップ用光学系、光ピックアップ装置及び記録・再生装置

(57)【要約】
【課題】　レーザ光源のモードホップ現象や高周波重畳に起因して発生する軸上色収差を効果的に補正でき、またレーザ光源の発振波長変化、温度・湿度変化、光情報記録媒体の保護層の厚みの誤差に起因して発生する球面収差の変動を簡易な構成で効果的に補正できる、光ピックアップ用光学系、光ピックアップ装置及び記録・再生装置を提供する。
【解決手段】　この光ピックアップ装置は、波長λが５００ｎｍ以下の光源１から出射された発散光の発散角を変え、対物レンズに入射させるためのカップリングレンズ２と対物レンズ７とを含む集光光学系を備え、集光光学系中の少なくとも２面以上に回折面を有する。また、屈折率分布を変化させて各光学面で生ずる球面収差等を補正できる屈折率分布可変素子５を備え、対物レンズ以外で発生する軸上色収差を回折面で発生する軸上色収差により相殺補正する。



【特許請求の範囲】

【請求項１】　波長λが５００ｎｍ以下の光源から出射された発散光の発散角を変え、対物レンズに入射させるためのカップリングレンズと対物レンズとを含む集光光学系を備え、

前記集光光学系中の少なくとも２面以上に回折面を有することを特徴とする光ピックアップ用光学系。

【請求項２】　波長λが５００ｎｍ以下の光源から出射された発散光の発散角を変え、対物レンズに入射させるためのカップリングレンズと対物レンズとを含む集光光学系を備え、

前記集光光学系中の少なくとも２面以上に回折面を有することを特徴とする光ピックアップ装置。

【請求項３】　光源からの光束を光情報記録媒体の情報記録面に集光する対物レンズと、

前記光源から出射された発散光の発散角を変え、前記対物レンズに入射させるためのカップリングレンズと、

前記光源と前記対物レンズの間に配置され、屈折率分布を変化させることにより各光学面で生ずる球面収差等を補正できる屈折率分布可変素子と、を備え、

前記カップリングレンズ、前記屈折率分布可変素子及び前記対物レンズの少なくとも１面に回折面を有し、

前記対物レンズ以外の光学素子で発生する軸上色収差を前記回折面で発生する軸上色収差により相殺補正することを特徴とする光ピックアップ装置。

【請求項４】　前記光源の波長が＋１０ｎｍ変化したときの前記カップリングレンズと前記対物レンズとの合成系の焦点位置の変化をΔｆＢ（μｍ）とし、前記対物レンズの像側開口数をNA_{obj}としたとき、

前記合成系の軸上色収差が次式を満たすことを特徴とする請求項３に記載の光ピックアップ装置。

$|\Delta fB \cdot (NA_{obj})^2| \leq 2.5\mu m$

【請求項５】　光源と、

前記光源の基準波長よりも１０ｎｍ短い波長に対して軸上色収差が過剰に補正された色補正光学素子と、

前記光源からの光束を光情報記録媒体の情報記録面に集光する対物レンズと、

前記光源と前記対物レンズとの間に配置され、屈折率分布を変化させることにより、各光学面で生ずる球面収差等を補正できる屈折率分布可変素子と、を備え、

前記色補正光学素子が前記対物レンズ及び前記屈折率分布可変素子で発生する軸上色収差を相殺補正することを特徴とする光ピックアップ装置。

【請求項６】　前記色補正光学素子が前記光源から出射された発散光の発散角を変え、対物レンズに入射させるためのカップリングレンズであり、

前記光源の波長が＋１０ｎｍ変化したときの前記カップリングレンズと前記対物レンズとの合成系の焦点位置の変化をΔｆＢ（μｍ）とし、前記対物レンズの像側開口数をNA_{obj}としたとき、

前記合成系の軸上色収差が次式を満たすことを特徴とする請求項５に記載の光ピックアップ装置。

$|\Delta fB \cdot (NA_{obj})^2| \leq 2.5\mu m$

【請求項７】　前記屈折率分布可変素子の材料が液晶を含み、該液晶に電場又は磁場又は温度を輪帯上に分割して印加することにより屈折率分布を変えることを特徴とする請求項３乃至６のいずれか１項に記載の光ピックアップ装置。

【請求項８】　前記屈折率分布可変素子は、透明電極層と電気光学材料層とが交互に積層されており、

前記透明電極層のうちの任意の層が輪帯上に分割され、その輪帯状に分割された透明導電層が複数の電極として機能し、

前記複数の電極を用いて前記電気光学材料層の屈折率を電気的に制御することにより屈折率分布を変えることを特徴とする請求項３乃至６のいずれか１項に記載の光ピックアップ装置。

【請求項９】　前記屈折率分布可変素子のアッベ数が次式を満足することを特徴とする請求項７または８に記載の光ピックアップ装置。

$80 > \nu d > 10$

【請求項１０】　前記屈折率分布可変素子が光軸と交わる領域付近に定電圧を加えることを特徴とする請求項７乃至９のいずれか１項に記載の光ピックアップ装置。

【請求項１１】　前記色補正光学素子の少なくとも１つの面が回折構造を有するカップリングレンズであることを特徴とする請求項５または６に記載の光ピックアップ装置。

【請求項１２】　前記カップリングレンズがプラスチック材料から形成されたことを特徴とする請求項１に記載の光ピックアップ用光学系。

【請求項１３】　前記カップリングレンズがプラスチック材料から形成されたことを特徴とする請求項２，３，４または１１に記載の光ピックアップ装置。

【請求項１４】　前記回折面は、マージナル光線の高さの最大値をh_mとすると、マージナル光線の高さｈが次式を満たす面に設けられていることを特徴とする請求項１または１２に記載の光ピックアップ用光学系。

$0.5h_m < h \leq h_m$

【請求項１５】　前記回折面は、マージナル光線の高さの最大値をh_mとすると、マージナル光線の高さｈが次式を満たす面に設けられていることを特徴とする請求項２、３、４、１１または１３に記載の光ピックアップ装置。

$0.5h_m < h \leq h_m$

【請求項１６】　前記対物レンズが１枚からなることを特徴とする請求項１，１２または１４に記載の光ピックアップ用光学系。

【請求項１７】　前記対物レンズが１枚からなることを特徴とする請求項２乃至４、１０、１３，１５のいずれ

か１項に記載の光ピックアップ装置。

【請求項１８】　前記対物レンズの光軸上の厚さをｄ、焦点距離をｆとしたとき、次式を満たすことを特徴とする請求項１６に記載の光ピックアップ用光学系。

０．９８＞ＮＡ＞０．７

０．８１＜ｄ/ｆ＜３．０

【請求項１９】　前記対物レンズの光軸上の厚さをｄ、焦点距離をｆとしたとき、次式を満たすことを特徴とする請求項１７に記載の光ピックアップ装置。

０．９８＞ＮＡ＞０．７

０．８１＜ｄ/ｆ＜３．０

【請求項２０】　前記対物レンズが次式を満たすことを特徴とする請求項１６または１８に記載の光ピックアップ用光学系。

$0.02 < \Sigma \phi_{chro} / \phi_{obj} < 0.30$

ここで、$\Sigma \phi_{chro}$ は回折レンズ面のパワーの和であり、ϕ_{obj} は対物レンズのパワーを示す。

【請求項２１】　前記対物レンズが次式を満たすことを特徴とする請求項１７または１９に記載の光ピックアップ装置。

$0.02 < \Sigma \phi_{chro} / \phi_{obj} < 0.30$

ここで、$\Sigma \phi_{chro}$ は回折レンズ面のパワーの和であり、ϕ_{obj} は対物レンズのパワーを示す。

【請求項２２】　前記対物レンズが２枚で構成されていることを特徴とする請求項１に記載の光ピックアップ用光学系。

【請求項２３】　前記対物レンズが２枚で構成されていることを特徴とする請求項２乃至４、１１，１３，１５のいずれか１項に記載の光ピックアップ装置。

【請求項２４】　前記対物レンズが次式を満たすことを特徴とする請求項２２に記載の光ピックアップ用光学系。

$0.02 < \Sigma \phi_{chro} / \phi_{obj} < 0.25$

ここで、$\Sigma \phi_{chro}$ は回折レンズ面のパワーの和であり、ϕ_{obj} は対物レンズのパワーを示す。

【請求項２５】　前記対物レンズが次式を満たすことを特徴とする請求項２３に記載の光ピックアップ装置。

$0.02 < \Sigma \phi_{chro} / \phi_{obj} < 0.25$

ここで、$\Sigma \phi_{chro}$ は回折レンズ面のパワーの和であり、ϕ_{obj} は対物レンズのパワーを示す。

【請求項２６】　前記カップリングレンズが正、負２枚のレンズからなることを特徴とする請求項６に記載の光ピックアップ装置。

【請求項２７】　前記カップリングレンズのアッベ数がそれぞれ次式を満たすことを特徴とする請求項２６に記載の光ピックアップ装置。

$\nu dP > 40.0$

$\nu dN < 60.0$

但し、νdP：正レンズのｄ線のアッベ数

νdN：負レンズのｄ線のアッベ数

【請求項２８】　前記対物レンズが１枚のレンズで構成され、前記レンズの光軸上の厚さをｄ、焦点距離をｆとし、次式を満たすことを特徴とする請求項２６または２７に記載の光ピックアップ装置。

０．９８＞ＮＡ＞０．７

０．８１＜ｄ/ｆ＜３．０

【請求項２９】　前記対物レンズが２枚のレンズで構成されることを特徴とする請求項２６または２７に記載の光ピックアップ装置。

【請求項３０】　前記光源と前記屈折率分布可変素子との間に配置され、結像面での波面収差の状態をモニタする光路分割素子を更に備えることを特徴とする請求項３乃至１１，１３，１５，１７，１９，２１，２３，２５乃至２９のいずれか１項に記載の光ピックアップ装置。

【請求項３１】　請求項２乃至１１，１３，１５，１７，１９，２１，２３，２５乃至３０のいずれか１項に記載の光ピックアップ装置を搭載したことを特徴とする音声および／または画像の記録装置、および／または、音声および／または画像の再生装置。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、光情報記録媒体の情報の記録および／または再生のための光ピックアップ用光学系、光ピックアップ装置、及びこの光ピックアップ装置を含む記録・再生装置に関するものである。

【０００２】

【従来の技術】レーザ光源の短波長化や対物レンズの高開口数化が図られてくると、ＣＤやＤＶＤのごとき従来の光ディスクに対して情報の記録または再生を行うような、比較的長波長のレーザ光源と低開口数の対物レンズとの組み合わせからなる光ピックアップ装置では、ほとんど無視できた問題でも、より顕在化されることが予想される。

【０００３】その１つがレーザ光源の微少な発振波長の変動により対物レンズで生じる軸上色収差の問題である。一般の光学レンズ材料の微少な波長変動による屈折率変化は、短波長を取り扱うほど大きくなる。そのため、微少な波長変動により生じる焦点のデフォーカス量は大きくなる．ところが、対物レンズの焦点深度は、$k \cdot \lambda / NA^2$（ｋは比例定数、λは波長、ＮＡは対物レンズの像側開口数）で表されることからわかるように、使用波長が短いほど焦点深度が小さくなり僅かなデフォーカス量も許されない。従って、青紫色半導体レーザのような短波長の光源及び高開口数の対物レンズを用いた光学系では、半導体レーザのモードホップ現象や出力変化による波長変動や、高周波重畳による波面収差の劣化を防ぐために、軸上色収差の補正が重要となる。

【０００４】更に、レーザ光源の短波長化と対物レンズの高開口数化において顕在化する別の問題は、温度・湿度変化による光学系の球面収差の変動である。すなわ

ち、光ピックアップ装置において一般的に使用されているプラスチックレンズは、温度や湿度変化をうけて変形しやすく、また、屈折率が大きく変化する。従来の光ピックアップ装置に用いられる光学系ではそれほど問題にならなかった屈折率変化による球面収差の変動も、レーザ光源の短波長化と対物レンズの高開口数化においては無視できない量となる。

【０００５】更に、レーザ光源の短波長化と対物レンズの高開口数化において顕在化する別の問題は、光ディスクの保護層（透明基板ともいう）の厚み誤差に起因する光学系の球面収差の変動である。保護層の厚み誤差により生じる球面収差は、対物レンズの開口数の４乗に比例して発生することが知られている。従って、対物レンズの開口数が大きくなるにつれて保護層の厚み誤差の影響が大きくなり、安定した情報の記録または再生が出来なくなる恐れがある。

【０００６】上記のような理由で発生する球面収差等の変動を補正する手法として光源から出射された発散光の発散角を変えて対物レンズに入射させるためのカップリングレンズと前記対物レンズの間隔を機械的に移動して球面収差を補正して光情報記録媒体の情報記録面上にスポットを結ぶことが行われてきた。

【０００７】しかし、レンズ系の全体、あるいは一部を移動させることは光ピックアップ装置の軽量化、コストダウンのためには不利であり、レンズ系を移動させずに上記球面収差等を補正できることが望ましい。

【０００８】

【発明が解決しようとする課題】本発明は、レーザ光源のモードホップ現象や高周波重畳に起因して対物レンズで発生する軸上色収差を効果的に補正できる光ピックアップ用光学系、光ピックアップ装置及び記録・再生装置を提供することを目的とする。

【０００９】また、レーザ光源の発振波長変化、温度・湿度変化、光情報記録媒体の保護層の厚みの誤差等に起因して光ピックアップ装置の各光学面で発生する球面収差の変動を簡易な構成で効果的に補正できる屈折率分可変光学素子を備えた光ピックアップ装置及び記録・再生装置を提供することを目的とする。

【００１０】

【課題を解決するための手段】上記目的を達成するために、本発明による光ピックアップ用光学系は、波長λが５００ｎｍ以下の光源から出射された発散光の発散角を変え、対物レンズに入射させるためのカップリングレンズと対物レンズとを含む集光光学系を備え、前記集光光学系中の少なくとも２面以上に回折面を有することを特徴とする。

【００１１】この光ピックアップ用光学系によれば、波長λが５００ｎｍ以下の光源から出射された発散光の発散角を変え、対物レンズに入射させるためのカップリングレンズと対物レンズとを含む集光光学系の少なくとも２面以上に回折面を有することにより、スポット径を小さくできかつ軸上色収差を良好に補正することができる。

【００１２】また、本発明による第１の光ピックアップ装置は、波長λが５００ｎｍ以下の光源から出射された発散光の発散角を変え、対物レンズに入射させるためのカップリングレンズと対物レンズとを含む集光光学系を備え、前記集光光学系中の少なくとも２面以上に回折面を有することを特徴とする。

【００１３】この光ピックアップ装置によれば、波長λが５００ｎｍ以下の光源から出射された発散光の発散角を変え、対物レンズに入射させるためのカップリングレンズと対物レンズとを含む集光光学系の少なくとも２面以上に回折面を有することにより、スポット径を小さくできかつ軸上色収差を良好に補正することができる。

【００１４】また、本発明による第２の光ピックアップ装置は、光源からの光束を光情報記録媒体の情報記録面に集光する対物レンズと、前記光源から出射された発散光の発散角を変え、前記対物レンズに入射させるためのカップリングレンズと、前記光源と前記対物レンズの間に配置され、屈折率分布を変化させることにより各光学面で生ずる球面収差等を補正できる屈折率分布可変素子と、を備え、前記カップリングレンズ、前記屈折率分布可変素子及び前記対物レンズの少なくとも１面に回折面を有し、前記対物レンズ以外の光学素子で発生する軸上色収差を前記回折面で発生する軸上色収差により相殺補正することを特徴とする。

【００１５】この光ピックアップ装置によれば、光源から出射された発散光の発散角を変え対物レンズに入射させるためのカップリングレンズと対物レンズとの間に配置された屈折率分布可変素子で屈折率分布を変化させることにより、各光学面で生ずる球面収差を補正ができ、カップリングレンズ、屈折率分布可変素子及び対物レンズの装置の少なくとも１面に設けた回折面で回折レンズ以外の光学素子で発生する軸上色収差を良好に補正することができる。

【００１６】また、第２の光ピックアップ装置において、前記光源の波長が＋１０ｎｍ変化したときの前記カップリングレンズと前記対物レンズとの合成系の焦点位置の変化をΔｆＢ（μｍ）とし、前記対物レンズの像側開口数をNA_{obj}としたとき、前記合成系の軸上色収差が次式（１）を満たすことが好ましい。

【００１７】

$$|\Delta fB\cdot(NA_{obj})^2|\leqq 2.5\mu m \qquad (1)$$

【００１８】また、本発明による第３の光ピックアップ装置は、光源と、前記光源の基準波長よりも１０ｎｍ短い波長に対して軸上色収差が過剰に補正された色補正光学素子と、前記光源からの光束を光情報記録媒体の情報

記録面に集光する対物レンズと、前記光源と前記対物レンズとの間に配置され、屈折率分布を変化させることにより、各光学面で生ずる球面収差等を補正できる屈折率分布可変素子と、を備え、前記色補正光学素子が前記対物レンズ及び前記屈折率分布可変素子で発生する軸上色収差を相殺補正することを特徴とする。

【００１９】この光ピックアップ装置では、各光学面で生ずる波面収差を補正する屈折率分布可変素子と対物レンズで発生する軸上色収差を色補正光学素子により相殺することができる。

【００２０】また、第３の光ピックアップ装置において前記色補正光学素子が前記光源から出射された発散光の発散角を変え、対物レンズに入射させるためのカップリングレンズであり、前記光源の波長が＋１０ｎｍ変化したときの前記カップリングレンズと前記対物レンズとの合成系の焦点位置の変化をΔｆＢ（μｍ）とし、前記対物レンズの像側開口数をNA_{obj}としたとき、前記合成系の軸上色収差が次式（２）を満たすことが好ましい。

【００２１】

$$|\Delta fB\cdot(NA_{obj})^2|\leqq 2.5\mu m \qquad (2)$$

【００２２】また、第２または第３の光ピックアップ装置において前記屈折率分布可変素子の材料が液晶を含み、該液晶に電場又は磁場又は温度を輪帯上に分割して印加することにより屈折率分布を変えるようにすることが好ましい。このように、屈折率分布可変素子の材料の液晶に電場又は磁場又は温度を輪帯上に分割して印加することにより、光学系の光軸に対してほぼ中心対称な屈折率分布を形成することができ、屈折率分布可変素子以外で発生する球面収差等の収差を補正できる。

【００２３】また、第２または第３の光ピックアップ装置において前記屈折率分布可変素子は、透明電極層と電気光学材料層とが交互に積層されており、前記透明電極層のうちの任意の層が輪帯上に分割され、その輪帯状に分割された透明導電層が複数の電極として機能し、前記複数の電極を用いて前記電気光学材料層の屈折率を電気的に制御することにより屈折率分布を変えることが好ましい。このような制御で屈折率分布を変えることにより、光学系の光軸に対してほぼ中心対称な屈折率分布を形成することができ、屈折率分布可変素子以外で発生する球面収差等の収差を補正できる。

【００２４】また、前記屈折率分布可変素子のアッベ数が次式（３）を満足することで対物レンズ等の他の光学素子から発生する球面収差を良好に補正することができる。

【００２５】$80>\nu d>10$　　　　（３）

【００２６】また、前記屈折率分布可変素子が光軸と交わる領域付近に定電圧を加えることにより、屈折率分布可変素子が光軸と交わる領域に近づくほど屈折率が小さくなる分布または、その逆の分布を容易に形成することができる。

【００２７】また、前記色補正光学素子の少なくとも１つの面が回折構造を有するカップリングレンズであることにより、対物レンズ等の他の光学素子で発生する軸上色収差を良好に相殺補正できる。

【００２８】また、前記カップリングレンズがプラスチック材料から形成されることで、回折構造や非球面を容易に付加することができ、かつ安価に大量生産することができる。

【００２９】また、前記回折面は、マージナル光線の高さの最大値をh_mとすると、マージナル光線の高さｈが次式（４）を満たす面に設けられていることが好ましい。

【００３０】

$$0.5h_m<h\leqq h_m \qquad (4)$$

【００３１】上述の式（４）を満たすようにすることで、回折レンズのマージナル光線高さでの輪帯ピッチを大きくすることができるため、ブレーズ形状誤差による光利用効率の低下を抑えることができる。例えば、薄肉レンズモデルで近似すると、光学系の軸上色収差は、次の数１の式で表される。

【００３２】

【数１】

$$\delta s'_\alpha=-\left(\frac{s'_\alpha}{h_1}\right)^2\sum_{j=1}^{\alpha}\frac{\phi_j h_j^2}{\nu_j}$$

S'α：最終レンズからガウス像面までの距離

ここで、ϕj（$j=1,2,3,\cdots,\alpha$）は各薄肉レンズの屈折力で、h_j（$j=1,2,3,\cdots,\alpha$）は各薄肉レンズを通るマージナル光線の光軸からの高さで、ν_j（$j=1,2,3,\cdots,\alpha$）は各レンズのアッベ数である。

【００３３】ここで、第ｋレンズに回折面を設け、その屈折力の一部を回折面に持たせる。回折による屈折力をϕ_dと表すと第ｋレンズの屈折力を$\phi_k=(\phi_k-\phi_d)+\phi_d$と置換し、$(\phi_k-\phi_d)$を屈折による屈折力$\phi_d$を回折による屈折力とし、それらのレンズが密着して配置されると考える。このとき、$(\phi_k-\phi_d)$の分のアッベ数はνkとなり、ϕ_dのアッベ数は回折面のアッベ数としてνdを表記する。この式を上述の数１の式に代入し

て、次の色消し条件を用いると次の数２の式が導かれる。

【００３４】

【数２】

$$\sum_{j=1}^{\alpha}\frac{\phi_j h_j^2}{\nu_j}+\left(\frac{1}{\nu_d}-\frac{1}{\nu_k}\right)\phi_d h_k^2=0$$

色消し条件 $\delta S'_\alpha=0$

従って、色消しのために必要な回折面の屈折力 ϕ_d は、次の数３の式で表すことができる。

【００３５】

【数３】

$$\phi_d=\left(\sum_{j=1}^{\alpha}\frac{\phi_j h_j^2}{\nu_j}\right)\Bigg/\left(\frac{1}{\nu_k}-\frac{1}{\nu_d}\right)h_k^2=\frac{C}{h_k^2}$$

ここで、上述の数３の式におけるＣは、次の数４の式で表せる。

【００３６】

【数４】

$$C=\left(\sum_{j=1}^{\alpha}\frac{\phi_j h_j^2}{\nu_j}\right)\Bigg/\left(\frac{1}{\nu_k}-\frac{1}{\nu_d}\right)$$

一方、回折面の光路差関数が、色消しのため、ほとんど２次であるから光路差関数を ϕ_d を用いると、次の数５の式で表せる。

【００３７】

【数５】

$$\Phi(h)=\frac{1}{2}\phi_d h^2$$

このとき、この回折面を輪帯状のブレーズ化したときのマージナル光線の高さ h_k での輪帯ピッチは、上述の数３の式を用いると、次の数６の式となる。

【００３８】

【数６】

$$P(h_k)=\frac{m\lambda}{\frac{d\Phi}{dh}}=\frac{m\lambda h_k}{C}$$

この数６の式より、マージナル光線の高さ、すなわち各レンズの有効径の最周辺部分での輪帯ピッチは、その光線高さに比例することが分かる。従って、マージナル光線高が高い面に回折面を配置する方が輪帯ピッチは大きくなる。輪帯ピッチが大きいほど、各輪帯のブレーズ形状誤差による回折効率の低下が起き難くい。

【００３９】また、前記対物レンズが１枚からなることで光ピックアップ装置のコストダウン及び軽量化を図ることができる。

【００４０】また、前記対物レンズの光軸上の厚さをｄ、焦点距離をｆとしたとき、次式（５）、（６）を満たすことが好ましい。式（６）は、ＮＡが０．７０よりも大きい単玉レンズにおいて良好な像高特性を得るための条件である。

【００４１】

０．９８＞ＮＡ＞０．７　　　　（５）

０．８１＜ｄ／ｆ＜３．０　　　　（６）

【００４２】また、前記対物レンズが次式（７）を満たすことにより、合成系の軸上色収差を良好に補正できる。

【００４３】

０．０２＜$\Sigma\phi_{chro}$ ／ϕ_{obj} ＜０．３０　　　　（７）

ここで、$\Sigma\phi_{chro}$ は回折レンズ面のパワーの和であり、ϕ_{obj} は対物レンズのパワーを示す。

【００４４】また、前記対物レンズが２枚で構成されていることにより、合成系の軸上色収差を良好に補正することができる。

【００４５】前記対物レンズが次式（８）を満たすことで合成系の軸上色収差を良好に補正できる。

【００４６】

$0.02<\Sigma\phi_{chro}/\phi_{obj}<0.25$ （８）

ここで、$\Sigma\phi_{chro}$ は回折レンズ面のパワーの和であり、ϕ_{obj} は対物レンズのパワーを示す。

【００４７】また、前記カップリングレンズが正、負２枚のレンズからなることで対物レンズ等の他の光学素子で発生する軸上色収差を良好に相殺補正できる。

【００４８】また、前記カップリングレンズのアッベ数がそれぞれ次式（９）、（１０）を満たすようにすると、更に良好な性能のカップリングレンズを得ることができる。

【００４９】$\nu dP>40.0$ （９）

【００５０】$\nu dN<60.0$ （１０）

但し、ν ｄ Ｐ：正レンズのｄ線のアッベ数

ν ｄ Ｎ：負レンズのｄ線のアッベ数

【００５１】また、前記対物レンズが１枚のレンズで構成され、前記レンズの光軸上の厚さをｄ、焦点距離をｆとし、次式を満たすことが好ましい。式（１２）は、ＮＡが０．７０よりも大きい単玉レンズにおいて良好な像高特性を得るための条件である。

【００５２】

$0.98>NA>0.7$ （１１）

$0.81<d/f<3.0$ （１２）

【００５３】また、前記対物レンズが２枚のレンズで構成されることにより、合成系の軸上色収差を良好に補正することができる。

【００５４】また、前記光源と前記屈折率分布可変素子との間に配置され、結像面での波面収差の状態をモニタする光路分割素子を更に備えることが好ましい。光路分割素子で結像面での波面収差の状態をモニタ等することにより、例えば光情報記録媒体の情報記録面カバー層厚みの変化に対して、結像面の波面収差の情報から屈折率分布可変素子の屈折率分布を変えることにより、情報記録面上に良好にスポットを結ぶことができる。

【００５５】また、本発明による記録・再生装置は、上述の光ピックアップ装置を搭載し、音声および／または画像の記録、および／または、音声および／または画像の再生を行うものである。

【００５６】この記録・再生装置によれば、レーザ光源のモードホップ現象や高周波重畳に起因して対物レンズで発生する軸上色収差を効果的に補正し、またレーザ光源の発振波長変化、温度・湿度変化、光情報記録媒体の保護層の厚みの誤差等に起因して各光学面で発生する球面収差の変動を効果的に補正できるので、安定かつ正確に記録・再生を行うことができる。

【００５７】

【発明の実施の形態】以下、本発明による実施の形態について図面を用いて説明する。図１は本発明の実施の形態による光ピックアップ用光学系、光ピックアップ装置を概略的に示す図である。

【００５８】図１に示す光ピックアップ装置（光ピックアップ用光学系）では、波長λが４００ｎｍ程度のレーザ光源１からの光束がカップリングレンズ２、プリズムペア３、偏向ビームスプリッタ４、屈折率分布可変素子５、及び絞り６を通過し、対物レンズ７によって光情報記録媒体の保護層９’を介して情報記録面９に集光される。情報記録面９からの反射光は、対物レンズ７及び屈折率分布可変素子５等を通過した後、偏向ビームスプリッタ４によって反射され光検出器系１０に向かう。対物レンズ７は２軸アクチュエータ８によりフォーカシング方向及びトラッキング方向に駆動される。

【００５９】また、図１の光ピックアップ装置は、図示しないが、情報記録面９からの反射光を検出することで集光光学系で発生した球面収差の変動を検出し、その検出結果に基づいて球面収差誤差信号を生成する球面収差検出手段を有する。球面収差誤差信号が零になるように、球面収差補正手段としての屈折率分布可変素子を駆動させる。このような球面収差検出手段、および球面収差検出手段における球面収差検出方法としては、例えば同一出願人による特願２００１－１０８３７８号に記載されているものを用いることができる。なお、上述の球面収差検出手段は、球面収差補正手段と光源との間の光路中に配置される。

【００６０】また、屈折率分布可変素子５は、カップリングレンズ２と対物レンズ７との間に配置され、レーザ光源１の発振波長変化、温度・湿度変化、光情報記録媒体の保護層９’の厚みの誤差等に起因して各光学面で発生する球面収差の変動を補正する。即ち、図１の集光光学系中で球面収差が変動した場合、この球面収差の変動を光検出器系１０で検出し、この検出された球面収差誤差信号に基づいて駆動手段５ａが屈折率分布可変素子５を駆動し、球面収差を補正する。

【００６１】次に、図１の屈折率分布可変素子５の例を図２、図３により説明する。

【００６２】図２に示す屈折率可変素子は、電気的に接続され光学的に透明な電極層ａ、ｂ、ｃと、電極層ａ、ｂ、ｃに対し電気的に絶縁され駆動手段Ａから印加される電圧に応じて屈折率分布が変化する屈折率分布可変素子ｄ、ｅとが交互に積層されて形成されており、電極層ａ、ｂ、ｃが輪帯状に複数の領域に分割されている。

【００６３】図２の屈折率可変素子で、複数の輪帯状の電極層ａ、ｂ、ｃに駆動手段Ａから電圧を印可し、屈折率分布可変素子ｄ、ｅを駆動することで光学系の光軸に対してほぼ中心対称な屈折率分布を形成でき、屈折率分布可変素子以外で発生する球面収差等の収差を補正でき

る。

【００６４】図３に示す屈折率可変素子は、液晶１ｉがシール部材１ｇ、１ｈにより封止されており、透明電極層１ｃ、１ｄを設けた透明基板１ａと１ｂとの間に挟まれている。透明基板１ａ、１ｂの内側に配向膜１ｅ、１ｆが設けられており、透明電極層１ｃ、１ｄは輪帯状に複数に分割されている。駆動手段Ａから印可される電圧に応じて液晶ｉの屈折率を輪帯状に変化させることにより、屈折率分布可変素子以外で発生する球面収差等の収差を補正できる。

【００６５】

【実施例】次に、本発明を実施例１～４により更に具体的に説明する。各実施例１～４におけるカップリングレンズ、対物レンズおよび合成系に関するデータの一覧を次の表１に示す。

【００６６】

【表１】

実施例1

使用波長 λ (nm)		405
カップリングレンズ	レンズ枚数	1
	回折面数	1
対物レンズ	レンズ枚数	1
	回折面数	1
	NA	0.85
	d/f	1.56
合成系	回折面数	2
	h1/hm	0.95
	h2/hm	1.00
	|Δfb| (μm)	1.01
	|Δfb·(NA$_{obj}$)^2| (μm)	0.73
	$\Sigma\phi_{dno}/\phi_{obj}$	6.34E-02

実施例2

使用波長 λ (nm)		405
カップリングレンズ	レンズ枚数	1
	回折面数	2
対物レンズ	レンズ枚数	2
	回折面数	0
	NA	0.85
合成系	回折面数	2
	h1/hm	0.86
	h2/hm	1.00
	|Δfb| (μm)	0.19
	|Δfb·(NA$_{obj}$)^2| (μm)	0.14
	$\Sigma\phi_{dno}/\phi_{obj}$	7.94E-02

実施例3

使用波長 λ (nm)		405
カップリングレンズ	レンズ枚数	2
	回折面数	0
	νdP	54.7
	νdN	23.8
対物レンズ	レンズ枚数	2
	回折面数	0
	NA	0.85
合成系	回折面数	0
	|Δfb| (μm)	0.03
	|Δfb·(NA$_{obj}$)^2| (μm)	0.02

実施例4

使用波長 λ (nm)		405
カップリングレンズ	レンズ枚数	1
	回折面数	2
対物レンズ	レンズ枚数	1
	回折面数	0
	NA	0.85
	d/f	1.50
合成系	回折面数	2
	h1/hm	0.85
	h2/hm	1.00
	|Δfb| (μm)	1.29
	|Δfb·(NA$_{obj}$)^2| (μm)	0.83
	$\Sigma\phi_{dno}/\phi_{obj}$	1.04E-01

※ここでh1、h2は回折レンズ面を通過するマージナル光線の高さである。

【００６７】また、各実施例１～４における屈折率分布素子による補正前と補正後の波面収差データを次の表２に示す。

【００６８】

【表２】

実施例1（単玉）回折面2面	球面収差変動の要因		補正前の波面収差	補正後の波面収差	屈折率分布
	基準状態		0.006λ	0.006λ	
	LDの波長変動	Δλ=+10nm	0.068λ	0.008λ	n(R)=n0(λ)-0.6684e-6R^4
		Δλ=-10nm	0.077λ	0.011λ	n(R)=n0(λ)+0.8007e-6R^4
	温度変化	ΔT=+30℃	0.073λ	0.006λ	n(R)=n0(λ)+0.7139e-5R^4
		ΔT=-30℃	0.078λ	0.01λ	n(R)=n0(λ)+0.1728e-3R^4
	透明基板厚さ誤差	Δt=+0.02mm	0.195λ	0.008λ	n(R)=n0(λ)+0.3433e-4R^4
		Δt=-0.02mm	0.188λ	0.008λ	n(R)=n0(λ)-0.4451e-3R^4

実施例2 回折コリ+2枚対物	球面収差変動の要因		補正前の波面収差	補正後の波面収差	屈折率分布
	基準状態		0.004λ	0.004λ	
	LDの波長変動	Δλ=+10nm	0.051λ	0.005λ	n(R)=n0(λ)-0.6840e-5R^4-0.2711e-4R^6
		Δλ=-10nm	0.083λ	0.008λ	n(R)=n0(λ)-0.2606e-4R^4+0.3635e-4R^6
	温度変化	ΔT=+30℃	0.014λ	0.004λ	n(R)=n0(λ)-0.1048e-3R^4-0.2339e-4R^6
		ΔT=-30℃	0.014λ	0.004λ	n(R)=n0(λ)-0.1085e-3R^4+0.2680e-4R^6
	透明基板厚さ誤差	Δt=+0.02mm	0.194λ	0.008λ	n(R)=n0(λ)-0.1839e-4R^4-0.8407e-4R^6
		Δt=-0.02mm	0.201λ	0.010λ	n(R)=n0(λ)-0.4380e-4R^4+0.1096e-3R^6

実施例3 2枚コリ+2枚対物	球面収差変動の要因		補正前の波面収差	補正後の波面収差	屈折率分布
	基準状態		0.008λ	0.006λ	
	LDの波長変動	Δλ=+10nm	0.038λ	0.004λ	n(R)=n0(λ)+0.5831e-4R^4-0.3160e-4R^6
		Δλ=-10nm	0.056λ	0.008λ	n(R)=n0(λ)-0.2277e-5R^4+0.2785e-4R^6
	温度変化	ΔT=+30℃	0.019λ	0.015λ	n(R)=n0(λ)+0.1764e-4R^4-0.1152e-5R^6
		ΔT=-30℃	0.011λ	0.004λ	n(R)=n0(λ)-0.7082e-4R^4+0.1906e-4R^6
	透明基板厚さ誤差	Δt=+0.02mm	0.197λ	0.006λ	n(R)=n0(λ)+0.5860e-5R^4-0.8651e-4R^6
		Δt=-0.02mm	0.190λ	0.020λ	n(R)=n0(λ)-0.3127e-4R^4+0.1108e-3R^6

実施例4（単玉）回折コリ+1枚対物	球面収差変動の要因		補正前の波面収差	補正後の波面収差	屈折率分布
	基準状態		0.005λ	0.005λ	
	LDの波長変動	Δλ=+10nm	0.142λ	0.007λ	n(R)=n0(λ)+0.1039e-6R^4-0.6275e-4R^6
		Δλ=-10nm	0.146λ	0.017λ	n(R)=n0(λ)-0.8168e-4R^4+0.9583e-4R^6
	温度変化	ΔT=+30℃	0.164λ	0.008λ	n(R)=n0(λ)+0.4840e-4R^4-0.8308e-4R^6
		ΔT=-30℃	0.154λ	0.007λ	n(R)=n0(λ)-0.2373e-2R^2-0.1339e-3R^4
	透明基板厚さ誤差	Δt=+0.02mm	0.199λ	0.007λ	n(R)=n0(λ)+0.1982e-2R^2
		Δt=-0.02mm	0.180λ	0.009λ	n(R)=n0(λ)-0.1922e-2R^2

※光軸をZ軸とすると R^2=X^2+Y^2

【００６９】なお、本実施例のレンズにおける非球面は光軸方向をＸ軸、光軸に垂直な方向の高さをｈ、屈折面の曲率半径をｒとするとき次の数７で表す。但し、κを円すい係数、Ａ２ｉを非球面係数とする。

【００７０】

【数７】

$$X=\frac{h^2/r}{1+\sqrt{1-(1+\kappa)h^2/r^2}}+\sum_{i=2}A_{2i}h^{2i}$$

【００７１】また、本実施例のレンズに設けた輪帯状の回折面は光路差関数Φｂとして次の数８により表すことができる。ここで、ｈは光軸に垂直な高さであり、ｂ２ｉは光路差関数の係数である。

【００７２】

【数８】

$$\Phi_b=\sum_{i=1}b_{2i}h^{2i}$$

【００７３】（実施例１）

【００７４】図１において光源に波長４０５ｎｍの青紫色半導体レーザを用い、１群１枚で開口数０．８５の対物レンズを用いた。１群１枚カップリングレンズの光源側と対物レンズの光源側とにそれぞれ回折面を形成することで軸上色収差を補正した。また、カップリングレンズの光情報記録媒体側の面と対物レンズの両面を非球面とすることで合成系の収差を精緻に補正した。保護層厚の誤差やレーザ光源のの波長変動等に起因する球面収差の変動は、カップリングレンズと対物レンズとの間に配置した屈折率分布可変素子で補正した。実施例１の光路図を図４に示す。また、実施例１のレンズデータを次の表３に示す。

【００７５】

【表３】

実施例1

面番号		r(mm)	d(mm)	Nλ	νd
0	光源		7.929		
1	カップリングレンズ	∞	1.000	1.525	56.5
2		-5.587	5.000		
3	偏光板	∞	2.000	1.53	64.1
4	基板	∞	1.000	1.53	64.1
5	液晶	∞	0.800	1.53	*
6	基板	∞	1.000	1.53	64.1
7		∞	5.000		
8	絞り	∞	0.000		
9	対物レンズ	1.247	2.750	1.525	56.5
10		-0.861	0.330		
11	透明基板	∞	0.100	1.619	30.0
12		∞			

非球面係数

第2面	κ	1.1783E+00
	A4	-1.1418E-03
	A6	6.7870E-04
	A8	4.4073E-05
	A10	-2.4035E-06

第10面	κ	-2.7384E+01
	A4	1.3778E-01
	A6	-3.2832E-01
	A8	2.6291E-01
	A10	-7.8115E-02
	A12	-2.5227E-04

第9面	κ	-7.0271E-01
	A4	2.0793E-02
	A6	-2.5985E-03
	A8	4.9919E-03
	A10	-2.2786E-04
	A12	-9.5332E-04
	A14	4.6404E-05
	A16	1.7553E-04
	A18	2.1430E-05
	A20	-2.9990E-05

回折面係数

第1面	b2	-1.3000E-02
	b4	1.7652E-03
	b6	-5.5596E-04

第9面	b2	-4.9893E-03
	b4	-3.7597E-04

【００７６】（実施例２）

【００７７】光源に波長４０５ｎｍの青紫色半導体レーザを用い、対物レンズとして２群２枚構成で開口数０．８５のレンズを用いた。１群１枚のカップリングレンズの両面を回折面とすることで、対物レンズで発生する軸上色収差を補正した。保護層厚の誤差やレーザ光源のの波長変動等に起因する球面収差の変動は、カップリングレンズと対物レンズとの間に配置した屈折率分布可変素子で補正した。実施例２の光路図を図５に示す。また、実施例２のレンズデータを次の表４に示す。

【００７８】

【表４】

実施例2

面番号		r(mm)	d(mm)	Nλ	νd
0	光源		18.000		
1	カップリングレンズ	-25.624	1.200	1.525	56.5
2		-18.149	10.000		
3	偏光板	∞	2.000	1.53	64.1
4	基板	∞	1.000	1.53	64.1
5	液晶	∞	0.800	1.53	*
6	基板	∞	1.000	1.53	64.1
7		∞	2.000		
8	絞り	∞	0.000		
9	対物レンズ	2.074	2.400	1.525	56.5
10		8.053	0.100		
11		0.863	1.100	1.525	56.5
12		∞	0.240		
13	透明基板	∞	0.100	1.619	30.0
14		∞			

第9面	κ	-1.2955E-01
	A4	-3.7832E-03
	A6	5.1667E-04
	A8	-1.1780E-03
	A10	-2.0626E-04
	A12	2.5941E-05
	A14	1.4917E-04
	A16	-5.1578E-05

第10面	κ	4.7554E+01
	A4	1.3641E-02
	A6	-2.9201E-02
	A8	-9.3339E-03
	A10	3.3011E-02
	A12	-2.2626E-02

第11面	κ	-7.1425E-01
	A4	1.3647E-01
	A6	-5.3414E-02
	A8	3.0269E-01
	A10	-1.6898E-01

回折面係数

第1面	b2	-1.1545E-02
	b4	-2.1408E-05

第2面	b2	-1.0955E-02
	b4	1.0713E-05

【００７９】（実施例３）

【００８０】光源に波長４０５ｎｍの青紫色半導体レーザを用い、対物レンズとして２群２枚構成で開口数０．８５のレンズを用いた。２群２枚構成のカップリングレンズは正、負接合レンズからなっており、対物レンズで発生する軸上色収差を補正した。保護層厚の誤差やレーザ光源のの波長変動等に起因する球面収差の変動は、カップリングレンズと対物レンズとの間に配置した屈折率分布可変素子で補正した。実施例３の光路図を図６に示す。また、実施例３のレンズデータを次の表５に示す。

【００８１】

【表５】

実施例3

面番号		r(mm)	d(mm)	Nλ	νd
0	光源		18.800		
1	カップリングレンズ	8.642	2.240	1.752	54.7
2		-4.629	1.420	1.914	23.8
3		3290.994	10.000		
4	偏光板	∞	2.000	1.53	64.1
5	基板	∞	1.000	1.53	64.1
6	液晶	∞	0.800	1.53	*
7	基板	∞	1.000	1.53	64.1
8		∞	5.000		
9	絞り	∞	0.000		
10	対物レンズ	2.074	2.400	1.525	56.5
11		8.053	0.100		
12		0.863	1.100	1.525	56.5
13		∞	0.240		
14	透明基板	∞	0.100	1.619	30.0
15		∞			

第10面		
	κ	-1.2955E-01
	A4	-3.7832E-03
	A6	5.1667E-04
	A8	-1.1780E-03
	A10	-2.0628E-04
	A12	2.5941E-05
	A14	1.4917E-04
	A16	-5.1578E-05

第11面		
	κ	4.7554E+01
	A4	1.3641E-02
	A6	-2.9201E-02
	A8	-9.3339E-03
	A10	3.3011E-02
	A12	-2.2626E-02

第12面		
	κ	-7.1425E-01
	A4	1.3647E-01
	A6	-5.3414E-02
	A8	3.0269E-01
	A10	-1.6898E-01

【００８２】（実施例４）

【００８３】光源に波長４０５ｎｍの青紫色半導体レーザを用い、対物レンズとして１群１枚構成で開口数０．８５のレンズを用いた。１群１枚のカップリングレンズの両面を回折面とすることにより、対物レンズで発生する軸上色収差を補正した。保護層厚の誤差やレーザ光源のの波長変動等に起因する球面収差の変動は、カップリングレンズと対物レンズとの間に配置した屈折率分布可変素子で補正した。実施例４の光路図を図７に示す。また、実施例３のレンズデータを次の表６に示す。

【００８４】

【表６】

実施例4

面番号		r(mm)	d(mm)	Nλ	νd
0	光源		17.900		
1	カップリングレンズ	-15.542	1.200	1.525	56.5
2		-18.813	9.000		
3	偏光板	∞	2.000	1.53	64.1
4	基板	∞	1.000	1.53	64.1
5	液晶	∞	0.800	1.53	*
6	基板	∞	1.000	1.53	64.1
7		∞	6.355		
8	絞り	∞	0.000		
9	対物レンズ	1.194	2.650	1.525	56.5
10		-0.975	0.355		
11	透明基板	∞	0.100	1.619	30.0
12		∞			

非球面係数

第9面	κ	-6.8335E-01
	A_4	1.6203E-02
	A_6	1.5491E-03
	A_8	2.8929E-03
	A_{10}	-3.6771E-04
	A_{12}	-3.5822E-04
	A_{14}	1.4842E-04
	A_{16}	1.1960E-04
	A_{18}	-3.0230E-05
	A_{20}	-1.1052E-05

第10面	κ	-2.1704E+01
	A_4	3.0802E-01
	A_6	-6.3950E-01
	A_8	5.8536E-01
	A_{10}	-2.1562E-01
	A_{12}	-2.5227E-04

回折面係数

第1面	b_2	-1.4664E-02
	b_4	-6.3363E-05

第2面	b_2	-1.4839E-02
	b_4	2.7506E-05

【００８５】なお、上述の表または図では、１０のべき乗の表現にＥ（またはｅ）を用いて、例えば、Ｅ－０２（＝１０^{-2}）のように表す場合がある。

【００８６】

【発明の効果】本発明によれば、レーザ光源のモードホップ現象や高周波重畳に起因して対物レンズで発生する軸上色収差を効果的に補正できる光ピックアップ用光学系、光ピックアップ装置及び記録・再生装置を提供できる。

【００８７】また、レーザ光源の発振波長変化、温度・湿度変化、光情報記録媒体の保護層の厚みの誤差等に起因して光ピックアップ装置の各光学面で発生する球面収差の変動を簡易な構成で効果的に補正できる屈折率分布可変光学素子を備えた光ピックアップ装置及び記録・再生装置を提供できる。

【図面の簡単な説明】

【図１】本発明の実施の形態による光ピックアップ用光学系、光ピックアップ装置を概略的に示す図である。

【図２】図１の屈折率分布可変素子の例としての屈折率可変素子を示す図である。

【図３】図１の屈折率分布可変素子の別の例としての屈折率可変素子を示す図である。

【図４】実施例１に関する光路図である。

【図５】実施例２に関する光路図である。

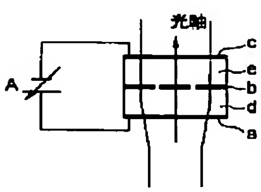
【図６】実施例３に関する光路図である。

【図７】実施例４に関する光路図である。

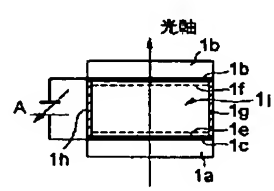
【符号の説明】

１　レーザ光源
２　カップリングレンズ
５　屈折率分布可変素子
７　対物レンズ
９　光情報記録媒体の情報記録面
９’　光情報記録媒体の保護層
１０　光検出器系

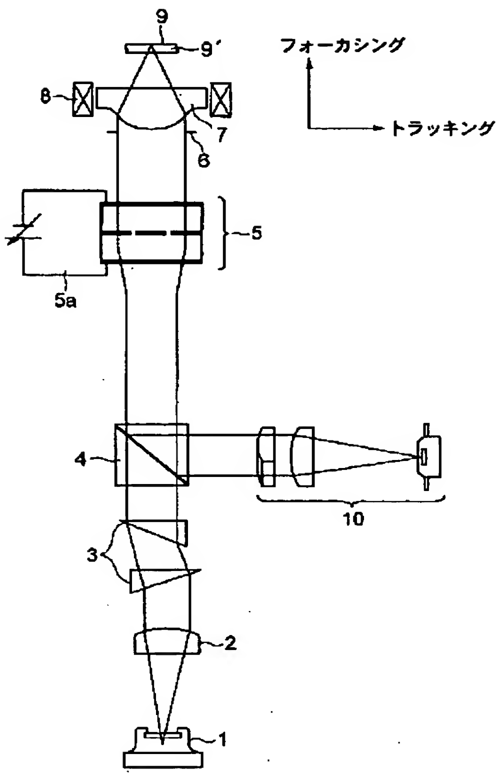
【図２】



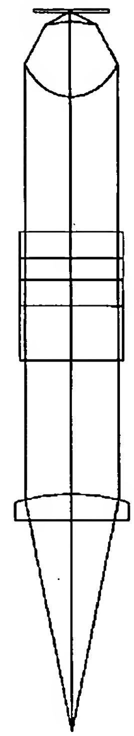
【図３】



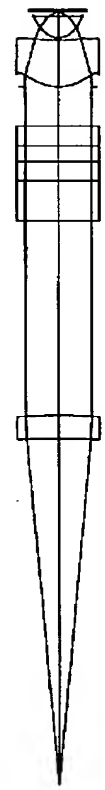
【図１】



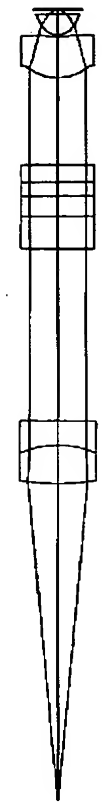
【図４】



【図５】



【図６】



【図７】